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Index to Advertisers and Classified Index Following Reading Matter.

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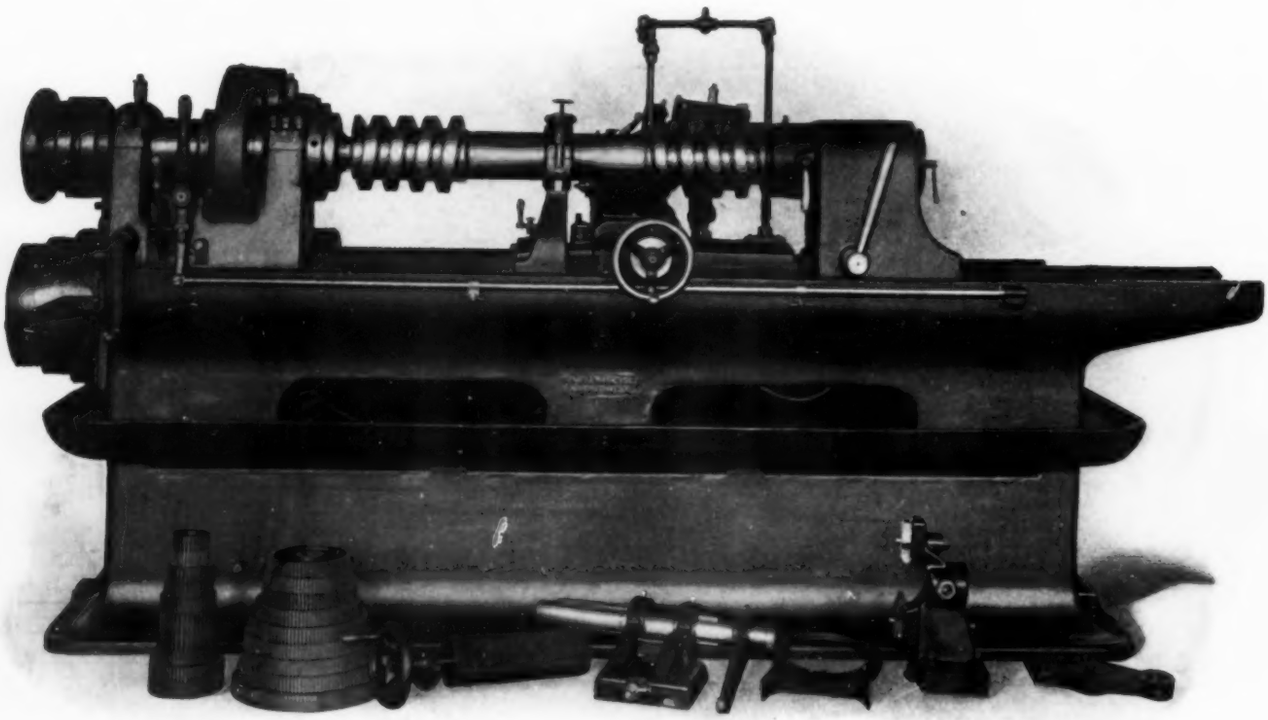

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The Works of the Union Twist Drill Company

A Plant Equipped For the Manufacture of Gear Cutters, Milling Cutters, Etc., with Facilities For Machining, Hardening and Testing

EDITORIAL CORRESPONDENCE

Some time ago, as our readers will remember, John A. McGregor, J. H. Drury, Mr. Boynton and others experienced in the manufacture and sale of milling cutters, twist drills, etc., formed a company and acquired the business of Gay & Ward of Athol, Mass., and set to work to enlarge and develop it. Since taking hold of the business they have increased its volume very much and are not only doing all the work they possibly can in the original building, but have in use a considerable addition to the plant, and soon will be using still another addition to it.

one of the most important sources of water power in the State of Massachusetts. The new management has enlarged the head race and lowered the water wheel, to make its position accord with the intentions (and drawings) of the original engineers of the power plant; and the factory is driven for the greater part of the year by a turbine water wheel, power being transmitted to the shop by rope drive. An engine, however, is held in reserve for emergencies, and is found necessary as an auxiliary source of power for a few weeks each year. Lighting is, of course, by

will be installed the cutting-off machinery, suitable apparatus being included for conveniently handling the material. Then comes the forge shop, and adjacent to this is the annealing department, Fig. 2, with a separate room for hardening and tempering. While the interior of the building as a whole is painted white, the hardening and tempering room has darkened walls and shutter-guarded windows to enable the men to judge heat colors closely, the light in the hardening room being practically uniform in intensity.

The various annealing furnaces are con-

FIG. 1. GENERAL VIEW OF WORKS OF UNION TWIST DRILL COMPANY, ATHOL, MASS.

Our illustration, Fig. 1, shows at the left the original building (with square tower) erected and used by Gay & Ward. This is still used in the machining operations of milling-cutter manufacturing. At the right of it the one-story building has been erected in which all stock for cutters is received, cut off, and chucked before going into the cutter factory; and in which also are located the hardening and tempering departments, etc.

Still farther to the right is a new building which will be devoted to the manufacture of twist drills. Much of the special machinery for this is already complete, and it is expected to be in full operation within a short time.

In the rear of the plant, as we see it in this view, and nearly parallel with the line of the buildings, runs Miller's river,

electricity, and generators now being installed will furnish current for the additions to the plant, the apparatus in the new building being arranged for motor drive.

The New Hardening Plant

This, the new building already referred to, is of brick, with ample skylights and with a concrete floor, except in that section which is to be used as a forge shop, where an earth floor is provided. Fire partitions and doors separate the various rooms, and all wires and pipes are carried in a subway which connects the building with the main shop, and when the drill shop is erected connection will be formed with it in similar fashion. The stock room for raw material is fitted up at one end of the building, and in the next room

nected with flues formed in the rear wall of the building, and in the erection of the structure provision was made as to flues, etc., for the installation of such additional furnaces as may be required in the future. The furnaces are arranged for oil fuel, and the pumps and pressure blowers for the system are located in a sub-basement to which the fluid flows from a large storage tank at the upper end of the grounds. The blower drive is by a direct-connected motor and the oil pump for the system is driven by a belt from the same source, so that if the air supply is cut off through the blower stopping for any reason, the pumping of oil ceases also.

In this section of the plant there are also two concrete tanks, one for brine and one for fresh water, for the service of the hardening department. These tanks are

each about 4 feet deep and 15 feet long, the brine tank being 8 feet and the other 6 feet in breadth. A rotary pump is provided to keep the salt water in circulation through the tanks in the hardening room, the return flow being through a cooling coil in the fresh-water tank. The water for the cooling tank is pumped from a well, the overflow being connected with the sewer. The arrangement of the tanks and piping will be seen in Figs. 3, 4 and 5.

Toilet facilities for the workmen employed in this building are installed in the basement proper, where ample wash rooms, shower baths, etc., are fitted up in excellent style, and the whole building and its equipment are admirable in every way.

Incidentally, the importance of the shower baths, etc., and a generally overlooked feature of the high-speed steel business, was noticed in the hardening department, where the higher heat required for hardening high-speed steel cutters, etc., was very noticeable; and it was stated in reply to an inquiry that the men handling this steel have to work a much shorter day than is the case when handling the carbon steels, simply because they cannot face the higher heats for the same length of time and keep themselves in condition for work requiring the closest care and attention.

In this establishment reliance is placed upon the best skilled and specially trained men to do the hardening. Oil furnaces and all needed facilities for absolute control of temperatures are provided; but beyond these the trained judgment of experienced men is entirely depended upon and declared to be better than any other known method for securing the best results. This conclusion, reached by men of the widest experience and applied in a case where the results attained vitally affect the degree of success that can be attained in the conduct of the business, is of special significance. It seems to be based mainly upon the fact that absolute uniformity in tool steel is not to be expected or hoped for under present conditions. Consequently where it is important to make each and

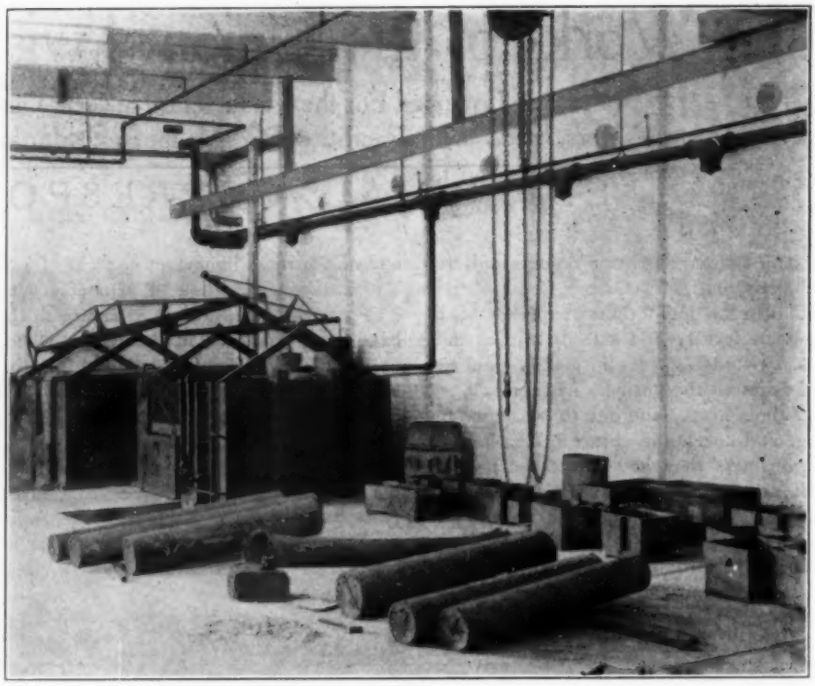


FIG. 2. CORNER IN ANNEALING ROOM

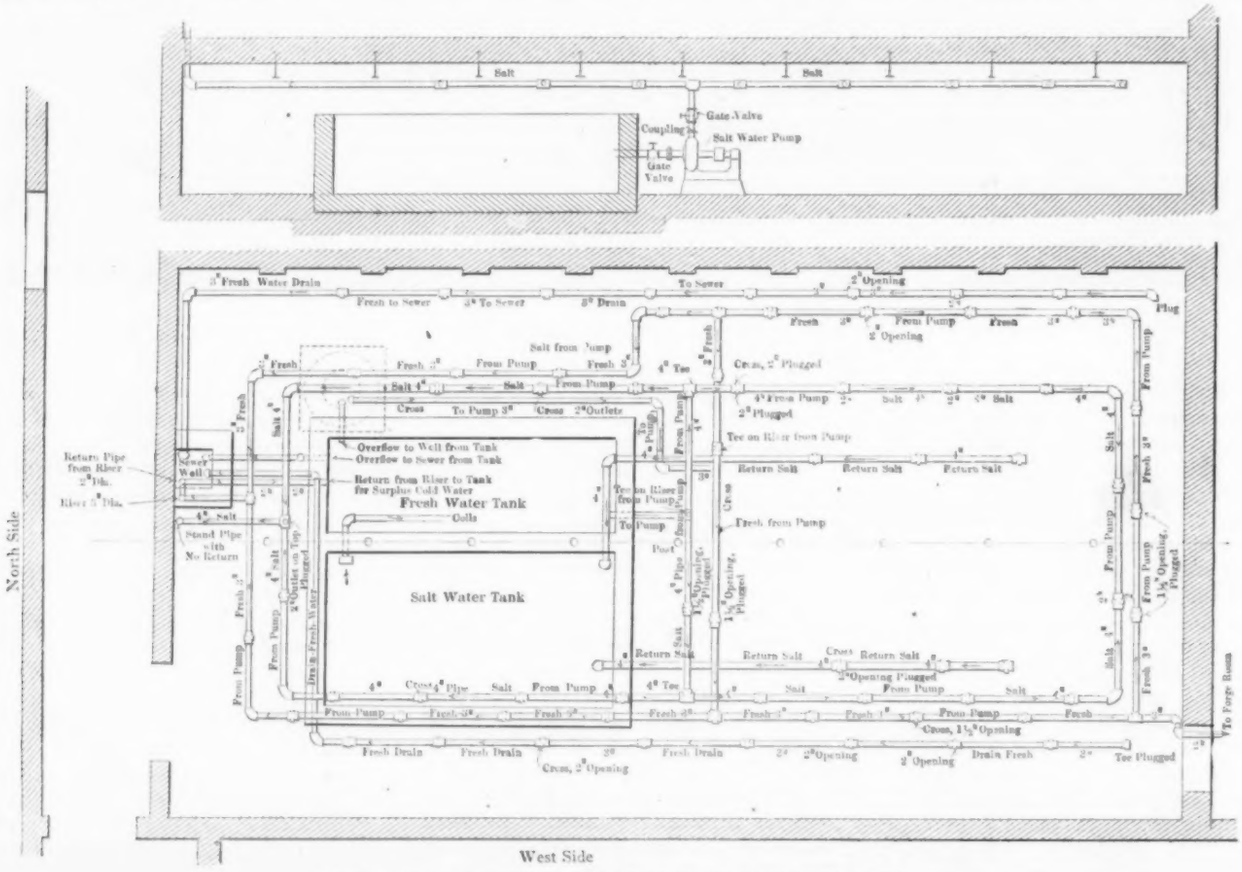
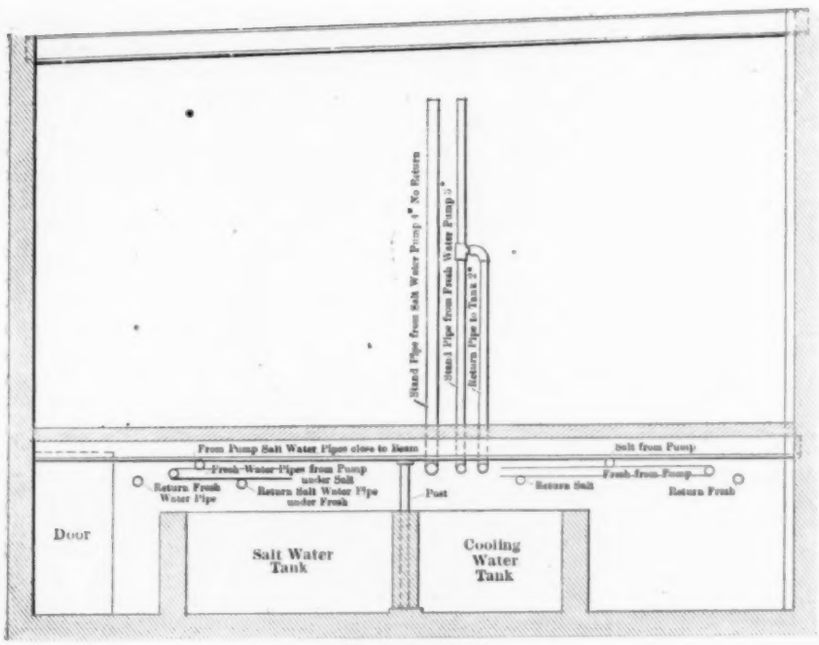


FIG. 3. PLAN OF PIPING IN BASEMENT OF HARDENING ROOM



Section looking North

FIG. 5. SECTION THROUGH TANKS

every tool as good as it is possible to make it, each tool made from a given bar must receive the heat treatment that has been shown to be required for that bar. This is determined by trial.

Among the other interesting appliances to be seen in this department is a vertical press, shown in the background in Fig. 6, under which saws that are likely to spring are held while being quenched in oil. The hot saw is placed on a circular base in the press and a ram is then operated by a lever, bringing a cap down firmly on the saw. Both the cap and the seat under the saw are provided with liberal grooves and oil passages, and oil under pressure is forced against the work, flooding it completely while it is still held fast in the press.

There are, naturally, a good many interesting processes involved in the manufacture of gear cutters and other formed milling cutters; much of the machinery employed is necessarily of a special character and numerous machines and fixtures of this class have been, or are being, devised and built at the Union works. For this reason the company maintains a well equipped pattern shop and has a tool department sufficiently extensive to take care of the construction of any apparatus of a special nature devised in the drawing office.

Cutter Blanks

As we all know, the first machine operation in the preparation of a cutter is to sever the blank from the bar—except where the cutter is so large as to require a forged blank. The cutting-off is accomplished at this shop in the rooms shown in Fig. 7, by Nutter & Barnes saws, and the parallelism of the faces of the blanks so severed seems somewhat remarkable, to say the least. A pile, say, two feet high, of 4- or 5-inch blanks each less than an inch thick, was noticed by the visitor standing near one of the saws and to both eye and touch the stack of disks appeared almost as upright and firm as

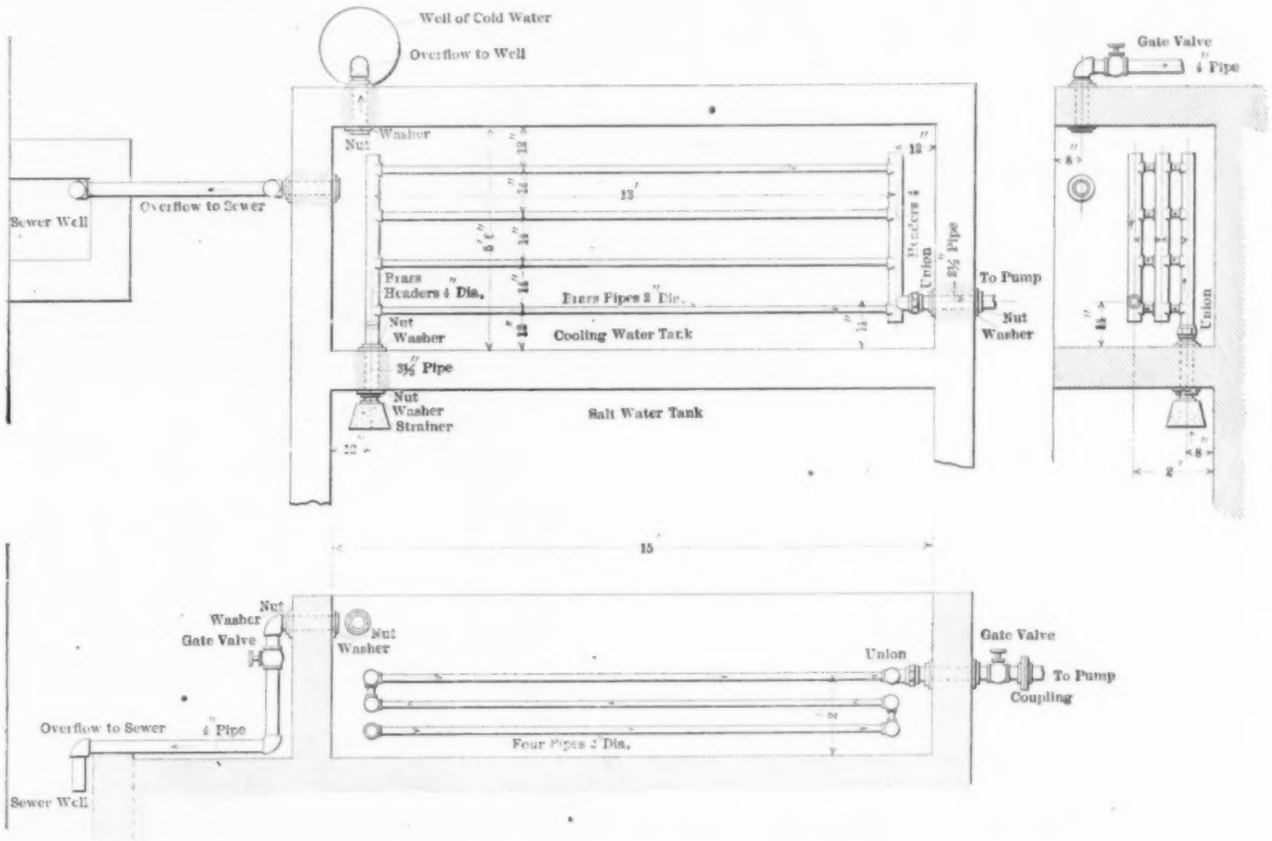


FIG. 4. TANKS IN BASEMENT OF HARDENING ROOM

a perpendicular bar of the same diameter and hight. It was evident upon inspection that very little time and stock need be wasted in bringing the blanks true and to proper thickness.

After the disks are chucked out, turned and faced, they are taken to the department illustrated by Fig. 8, placed in the lathe and turned or formed to the desired contour. If of the formed variety, after the stock between the teeth is milled out the cutters are ready for relieving or backing off. Take the case of a lot of involute gear cutters: These are strung on an arbor after forming and then notched in an automatic gear-cutting machine, after which they are backed off. There are gears with the spindle so that the speed of rotation of the cam relatively to the spindle can be varied to suit the number of teeth in the cutter. Cams of various throws are provided to suit the different cutters and these are readily put on the cam shaft or removed when changing from one job to another. In the train of gearing connecting the spindle and cam shaft is introduced a gear which is adjustable about the face of a disk keyed to one of the shafts in the train. By loosening the clamping screws in this gear the work spindle may be rotated by hand independently of the cam shaft to turn the cutter to the proper position before starting the relieving cut.

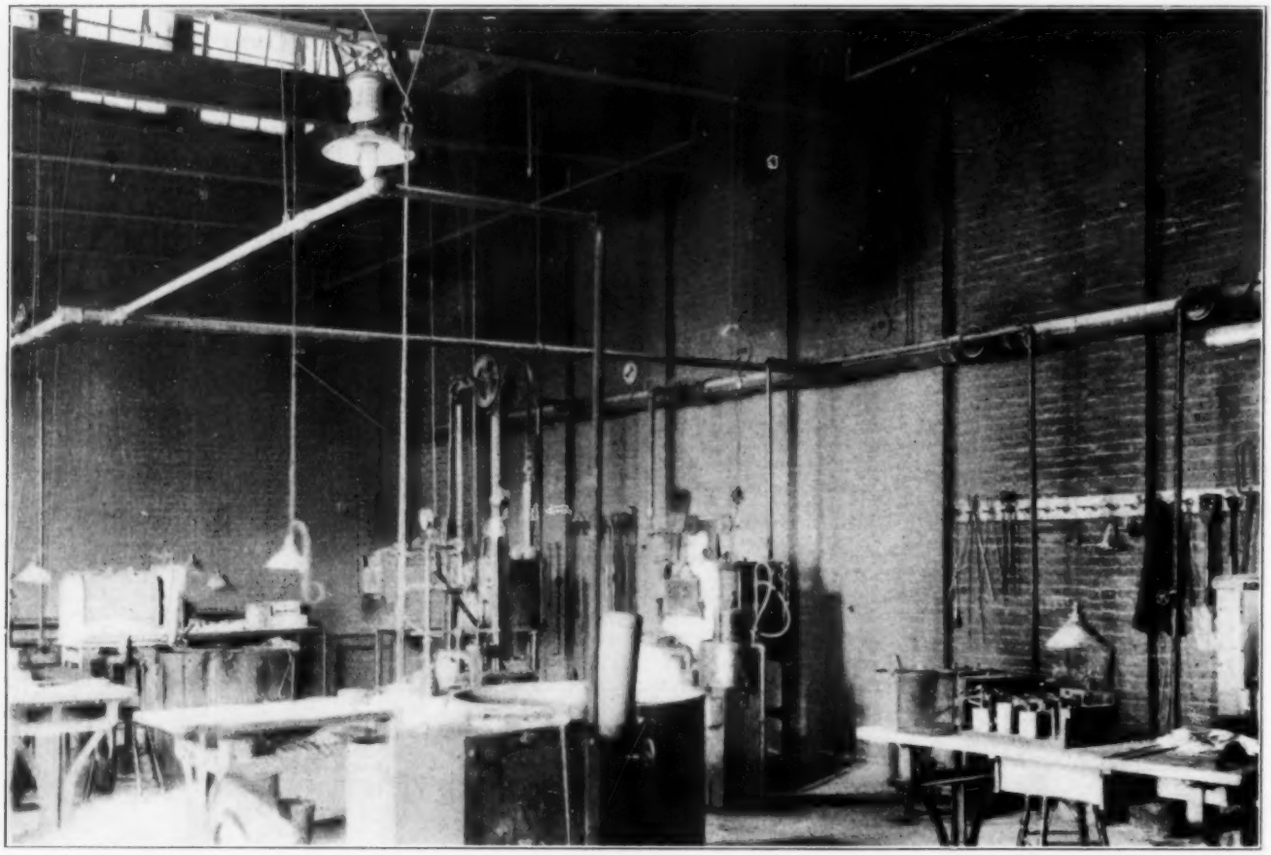


FIG. 6. CORNER IN THE HARDENING ROOM

half a dozen machines here equipped with cam-operated backing-off attachments arranged for this work.

Backing-off Machines

These millers have a type of head, with horizontal spindle, which is raised and lowered in its seat by a hand wheel to adjust the cutter arbor to the desired hight, the table being without vertical adjustment.

The cutter to be backed is secured on the arbor and the backing-off tool is held in a fixture carried by a horizontal slide which is operated by a cam to bring the forming tool into action as each cutter tooth comes opposite the tool. The cam shaft is connected by a series of change

The fixture carrying the forming tool is provided with screw adjustment for setting the tool forward to the cut and by this device the tool may be fed in by any desired amount after each cut has been taken over the series of teeth. Transverse adjustment is also provided to bring cutter and tool central laterally with each other, and for finishing such cutters as require side relief an arrangement is provided which gives the tool slide a slight lateral movement in addition to the forward stroke imparted by the cam. Involute gear cutters of the coarser pitches are given beside the radial relief a side clearance of a few thousandths to prevent any tendency toward dragging in the cut, and in backing off these cutters two cuts are necessary, the tool relieving first one side and then the other. The very slight decrease in thickness as the faces of the teeth of these side-relieved cutters are ground back, is compensated for in practice by sinking a little deeper into the gear blank.

An entirely new and original machine has been designed here for this backing-off operation. With this machine, the drawings of which were shown the writer and which will be exceedingly massive and powerful, it will be possible to quickly set indexes, so that the machine will then give to the backing-off tool any desired radial or lateral motion or any desired combination of the two, and by merely setting to the proper graduations a cutter may be backed off, and at the same time given side clearance (in one direction) to any desired degree, or in any desired proportion. We are all familiar with the expression, "It looks well on paper," and many distrust it. But being more or less familiar with Mr. Boynton's previous work along this line, we feel very confident that the machine will be as good in iron and steel as it looks on paper—and that is saying a good deal.

As an example of the thoroughness of design of the new work now going on in the equipment of the works with special machinery, we give at Fig. 9 a longitudinal

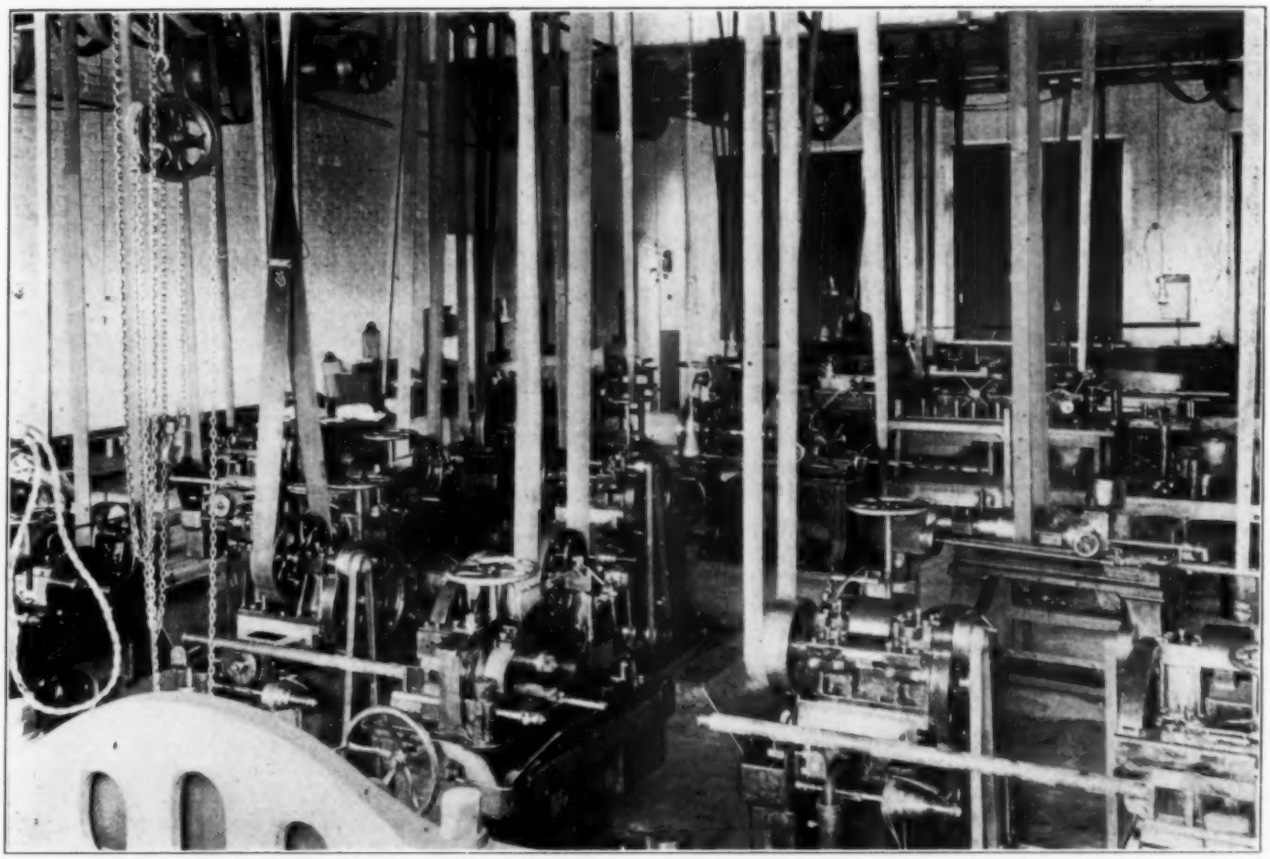


FIG. 7. CUTTING-OFF DEPARTMENT

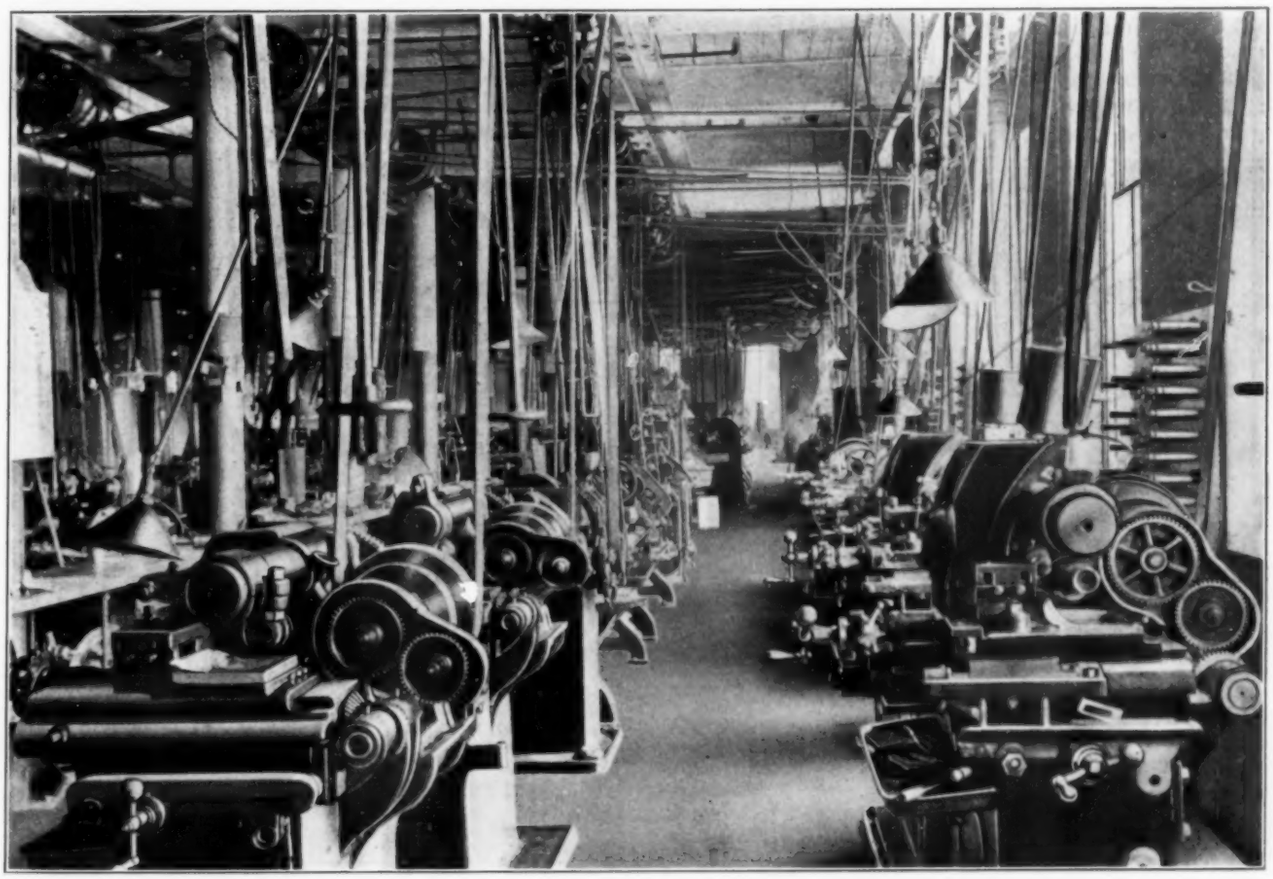


FIG. 8. FORMING DEPARTMENT

section through the spindle and bearings of a small special milling machine, which is now being built in the machine shop.

In this machine the usual arbor arrangement for holding the milling cutter was entirely abandoned, and the cutter is simply forced up against the hardened and ground end of the spindle nose. This is done by means of a rod which passes through the spindle, and which has a head upon it, as shown, so formed that the seat for the cutter, the inner edge of the head, and the cylindrical shank fitting the spindle nose can all be hardened and finished by grinding. With this construction it is easy to secure initial accuracy and to restore it whenever, by accident or wear, it may have become impaired.

This rod is drawn up by a nut at the rear end of the spindle, where it is flatted, as shown, and passes through a hardened and ground-steel bushing, having a flatted hole to receive it, and keep it from turning. This flatting is not for driving the cutter, but to prevent twisting of the rod when tightening the nut, which, if allowed to take place, prevents proper tightening and tends to subsequent loosening in use.

The main bearing, as will be seen, is conical, and is taken up by shifting the driving pulley *A* upon the spindle by means of the threaded collar, as shown. The rear bearing is tapered outside and is adjusted in the usual manner.

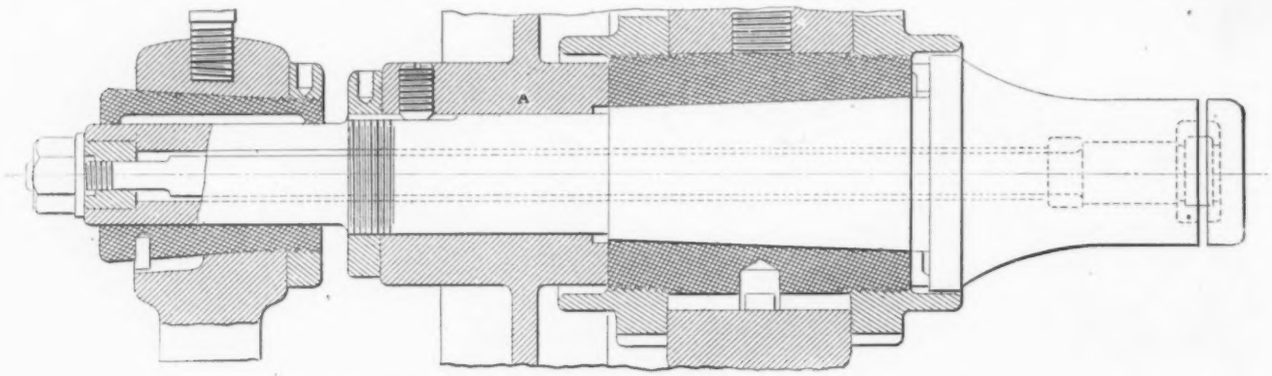


FIG. 9. LONGITUDINAL SECTION THROUGH SPINDLE OF SPECIAL MILLER

Preparing the Form Tool for the Backing-off Operation

The slot in the tool-holding fixture is made somewhat wider than the tool shank and the latter is set up hard against one side of the slot by set screws. This working side of the slot is scraped square with the spindle and it is necessary that the corresponding surface of the shank be ground parallel with the center line of the formed portion of the tool.

After the tool is formed out (an operation accomplished in the shaper by the aid of special holding fixtures and a lapped male master tool) and hardened and ground, it is clamped in an open-side fixture in a lathe and a cut is taken down a thin disk of soft material with one side of the tool. The work arbor is then reversed on the centers, and the untried side of the form tool brought up to the formed side of the disk. If they match, the tool is evidently square with the centers; if not, it is tapped around a little in its fixture and another test cut taken.

The fixture is provided with two finished faces at right angles to each other and one of these is fitted with a tongue for locating it squarely on the lathe cross slide; the other face is

FIG. 10. MILLING DEPARTMENT

adapted to be clamped to a surface grinder table, and when the tool has been set square by means of the disk, it is also true with the latter face. Upon the fixture being removed to the grinder with the tool still in place, it is clamped on this face and the guiding side of the tool shank is then uppermost, and in a position where it may readily be ground true with the formed part of the tool without shifting the clamps which secure it in the fixture. After this grinding operation the tool is ready to be put in its holder on the backing-off machine, the ground side of the shank assuring its being held square with the work.

Thus there is absolute assurance that every formed cutter will be "square;" i.e., that, in the case of a gear cutter, for instance, the sides of all the teeth it cuts will be alike, and each tooth exactly symmetrical about a radial line passing through its center. This important condition does not depend upon the operator who sets up the machine, nor can it be defeated by accidental displacement. It is a necessary consequence of the manner in which the forming tool that shapes the cutter is made.

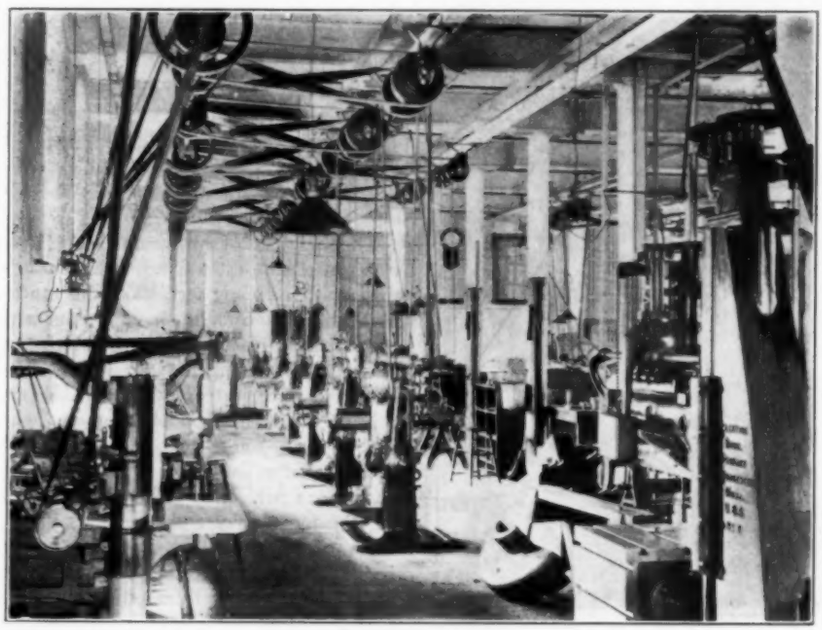


FIG. 11. TOOL-MAKING DEPARTMENT. SAFE FOR TEMPLETS IN DISTANCE

Marking Cutters

When the relieving operation is completed the cutters are taken to the milling machines, in the department shown in Fig. 10, where a slight cut is taken over the face of each tooth to give it a square, clean surface. Another operation then in order is the stamping of the firm name and certain data on the cutter face. This is accomplished in a form of foot press which has on its ram a vertical disk in whose periphery is inserted a series of steel stamps covering the alphabet, numerals 0 to 9 and other characters. The table beneath is a flat circular plate with a hub at the center to receive and locate the cutter. The stamping disk is readily indexed to bring the desired characters one after another over the work, the latter at the same time being indexed with its table. As the ram is operated by a foot treadle the operator has both hands free to attend to the indexing.

In marking shanks of end mills, drills, collets, etc., where the characters can be rolled in, a machine is employed which has a die carrier arranged to reciprocate on a horizontal rail located over a work table. The dies for the various purposes are made to a common size so that any die wanted may be easily secured in the seat in the lower edge of the reciprocating head. This member is actuated by a coarse-pitch screw driven by bevel reversing gears whose controlling clutch is operated at any required point in the traverse of the head, by adjustable tappets on a rod leading into the gear case. The work is placed on a plate on the table which is set to bring it to the necessary hight, and as the die passes along the impression is rolled into the shank, and the head then returns along the rail. In the case of taper shanks the plate beneath the work is inclined sufficiently to bring the upper line of the shank parallel with the face of the die, thus obviating the necessity for different dies for each class of shanks.

The reciprocating slide is always under the operator's control and by pressing with his knee upon a lever connected with the driving gear clutch he can regulate the movement of the head and die to a nicety, a feature of especial advantage when setting up for new jobs.

A Gear-cutter Test Gage

A view in the tool-making department is given in Fig. 11 and one in the inspection room in Fig. 12.

An ingenious device is used in the inspection department for proving the accuracy of gear-cutter teeth after the hardening process, and a similar instrument is made use of in that section of the cutter department which is devoted to backing-off operations. The cutter is mounted in the fixture on a horizontal plug at right angles to which is a long narrow guide containing a steel slide whose front end is narrowed down to form a suitable nose for contacting with the tops of the cutter teeth. This sliding member carries a pivoted indicator arm which has at its front end a pair of hooked jaws while the rear end swings over a series of graduations on the slide. When this slide is brought forward against the top of a tooth one of the hooked jaws is brought by spring pressure into contact with the side of the tooth at about the pitch line. Now, as the cutter is slowly turned by hand the indicator jaws test first one side of the tooth and then the other, along a line concentric to the relieved periphery and should there be any inaccuracy in the tooth thickness, or any variation between the different teeth due to deformation in hardening or other cause, it will be shown by the indicator.

This instrument is particularly handy in testing side-relieved gear cutters, and facilitates the operating of the backing-off machine, as it shows exactly the amount of clearance given and whether the relief is uniform for both sides of the teeth.

A little reflection will show the importance of this test upon the accuracy of gears cut with a given cutter. For if a cutter will not stand such a test it will cut badly formed gear teeth when its cutting faces have been ground back in sharpening; no matter how accurate it may be when new.

A Taper Gage

Another gage used in the inspection department is for testing tapers and consists of a pair of steel jaws, hardened, ground and lapped and secured to the face of an open vertical plate at the top of a stand which may be moved about on the bench. The jaws are about ⅜ inch thick, and are mounted one above the other with their facing edges representing exactly the opposite lines of a standard taper. As the workman sits at the bench before a window the gaging jaws are about on a level with the eye, and, as the supporting frame is entirely open so as not to obstruct the light, when the piece to be tested is slid in between the jaws the quality of the fit is seen at

once. While sliding the work into the gage the operator gently rocks both ends of the piece to and fro with his fingers and knows by the "feel" when it is seated properly to depth.

Tang-milling Fixtures

Tangs are milled on taper shanks, collets, etc., in a pair of duplicate fixtures placed at opposite ends of a miller table, the boy operator putting the work in one fixture while the piece in the other is being operated upon by a pair of straddle mills. Each fixture is bored horizontally to receive a hardened and ground bushing having a taper hole to fit the work and the latter upon being slid into its taper seat from the rear end is clamped by a set screw acting upon a hardened shoe fitted in the upper wall of the bushing. This shoe is fitted in place before the bushing is finished and the whole thing is then ground out together so that the bearing upon the taper work is perfect.

The knee of the miller upon which this operation is performed, when once adjusted to bring the center of the work level with the center of the cutter spindle, is locked positively against further adjustment, and similarly the saddle when once properly set is locked against transverse adjustment on the knee. For each size of taper there is a special pair of convex cutters and these are kept on their own arbors, each of which is provided with a shoulder at the large end of its taper shank and when the arbor is drawn into the spindle tight against this shoulder the cutters come central with the work fixtures. Thus changing from one job to another involves simply the changing of the arbor in the spindle and the bushings in the fixtures, and the work must necessarily come right.

A Cutter Grinder

An interesting type of cutter grinder built here is equipped with a vertical spindle which carries a small cupped emery wheel, the work being moved to and fro past the wheel by a hand-reciprocated table, which, being mounted upon a series of rolls is operated with ease, in fact may almost be moved by the mere pressure of a finger at the end. The rolls are hardened and ground and are about ¾ inch diameter by 4 inches long. They are mounted quite closely together in a retaining rack or frame and roll between two unannealed steel plates which are carefully scraped to a straight edge, the seats in the bed and slide to which these plates are attached being also scraped true.

The wheel spindle is carried by a vertically adjustable head and driven by a cemented belt from a drum at the rear which is supported between self-alining bearings that may be adjusted when necessary in order to maintain the proper tension on the belt.

For various reasons, we have by no means exhausted the list of interesting and instructive examples of special appliances and machines that have been and are being installed here; but we hope to be able to present others in future issues.

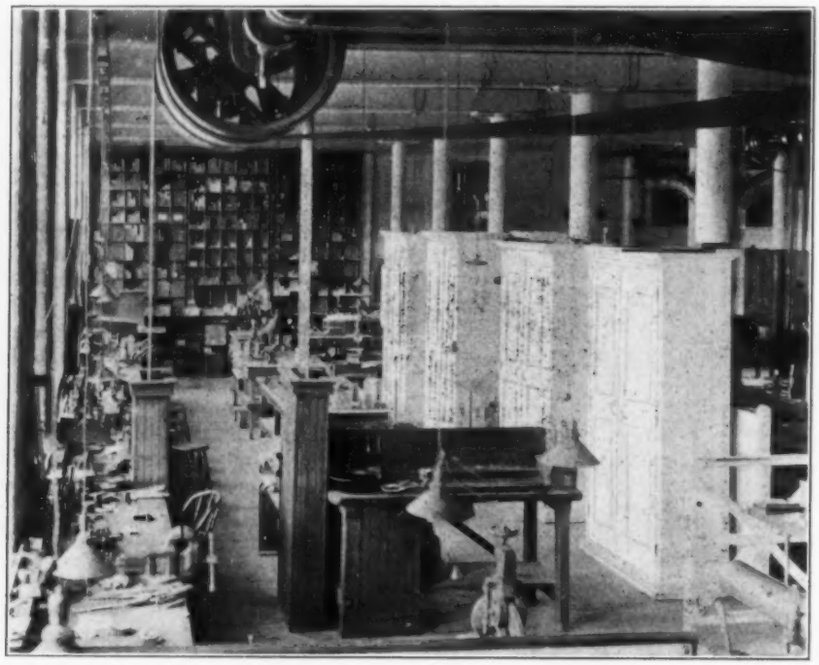


FIG. 12. INSPECTION DEPARTMENT

Modeling Wax—Best yellow wax 50, Venice turpentine 7, lard 3¼, bole elutriated 36. Mix and knead thoroughly. Or, best white wax 20, and while cooling add flake white 1.

Sectionalized Air Compressors

By Frank Richards

Those who write the "filler" paragraphs which are often called for to piece out and complete the columns of reading matter in the technical papers, do not always realize their responsibility. As a consequence we often see incorrect or misleading statements thus given extensive circulation, for these filler paragraphs are often welcome to other publications with emergent spaces to fill, and so they are apt to have extensive reproduction; and these short items are also much surer to be read than pieces which are longer and more pretentious. Here is a little item, recently clipped from a technical publication, which ought not to be allowed to go unchallenged.

"A sectionalized machine when erected where it was made may be as efficient as one of any other form; but it is not so at the end of a long and difficult journey when rust and rough usage have destroyed the accurately machined surfaces, and parts and connections have possibly been lost on the way. In such cases considerable skill is necessary to construct even a workable machine from the damaged remnants."

Sectionalized Machines Develop Full Efficiency

The builders of air compressors have, perhaps, the fullest warrant to speak upon this topic, for many sectionalized compressors have been built, have been transported under astonishing difficulties to places almost impossible of access, have been put into successful operation, and continue with undiminished output year after year. These machines, practically without exception, develop full efficiency, and are as perfect in action, after surviving the most risky and strenuous vicissitudes of transportation, as when erected for testing in the shop. "Rust and rough usage" have practically no effect upon any part of one of these machines to prevent its fulfilling perfectly its function. The machine when finally erected is not made up of "damaged remnants," but of parts which are all in good condition.

The Separate Parts

Fig. 1 shows all the component parts of a sectionalized Ingersoll-Sergeant piston inlet compressor, and Fig. 2 shows a machine (not the same machine) as re-erected in the mountain fastnesses of Mexico, with no suggestion about it of incompleteness or of inefficiency. Looking at the large collection of separated parts in Fig. 1, it will be seen that a great number of them are comparatively small and light, so that they can be boxed securely and thus be perfectly protected without having the package exceed the usual limit of 300 pounds. Some of the larger pieces, parts of the bedplate, fly-wheel, cylinders, shaft, etc., are made so that the weight of them without packing will be close to the limit. These also can be boxed or other-

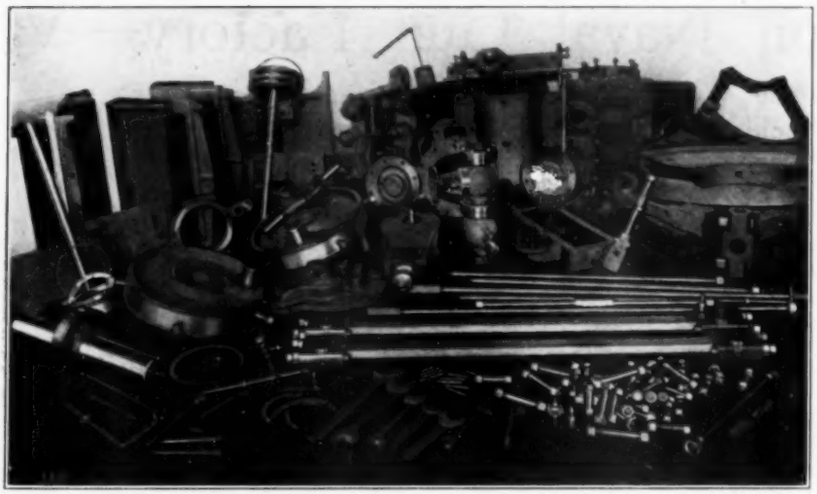


FIG. 1. PARTS OF A SECTIONALIZED AIR COMPRESSOR

wise so packed that for the greater portion of the usually long journey, often by sea, they will be perfectly safe from rust or mutilation until the mule-back jaunt, which is usually the last of the trip, when they can be unboxed and stripped of everything, the machined surfaces being still protected by cloth wrappings or otherwise, as much as may be necessary, and so in one way or another all the parts will arrive at their ultimate destination in perfect condition. This is the usual way; even mule-back transportation or other emergent conveyance is not likely to be undertaken unless there is good assurance that in the given case it is both possible and practicable.

Running with Parts Missing

When it comes to getting a machine into running condition with some of the vital parts missing, as suggested in the latter portion of the paragraph, that is another matter. We have no knowledge of any kind of skill which, for instance, could make a satisfactory fly-wheel with a single piece of it—a twelfth or a twentieth of it—missing, and the loss of some other part, as a piece of a cylinder, would suggest a task still more difficult. The builders of compressors are not likely to be giving many guarantees as to the usability of vulgar fractions of machines even if the percentage of numerator deficiency is small. Perfect duplication and interchangeability count for much in this matter. Of course, a machine of this character would be accompanied by a good stock of duplicate parts, and if anything was lost some of these might come in to help out at the very beginning.

Fig. 3, which shows a sectionalized duplex Rand machine with four single-stage air cylinders all of the same size, using the same—that is, perfectly duplicating—valves and other parts, suggests how a sectionalized compressor might be able to run with some most responsible members missing. The piping is arranged so that each air cylinder may be cut out of the service, if necessary, and the compressor might actually be run with either one, two, three, or four cylinders, and the cylinders not in use might be actually absent without affecting the efficiency of what might be present and working.

Sectionalized Machines Cost More Money

This machine, Fig. 3, it will be noticed, is driven directly by water wheels on the main shaft. Such sectionalized machines are driven also by electric motors, so that with the three available drives of steam, water, or electricity there is quite a respectable and continuous demand for sectionalized compressors for the earliest workings in the hitherto inaccessible spots in the mountains where valuable minerals are hid. When mining properties develop sufficient value to warrant it there is later in almost every case some means of communication and transport provided, and the sectionalized machine while doing most valuable pioneer work is never to be regarded as a permanent and altogether best installation. The cost alone of such machines is sufficient to prevent their use except where absolutely required.

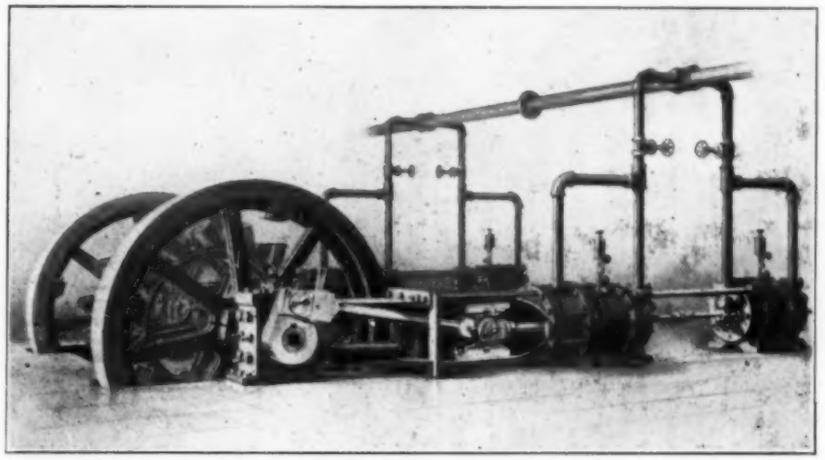


FIG. 3. A COMPRESSOR WITH DUPLICATE CYLINDERS

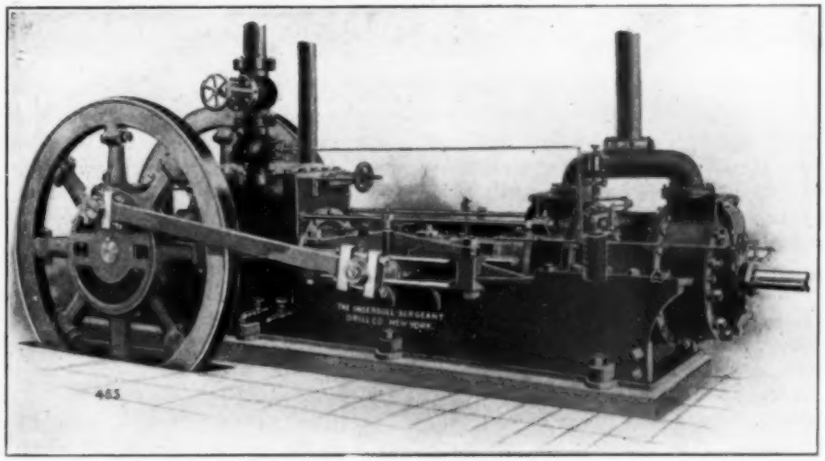


FIG. 2. THE COMPRESSOR READY FOR WORK

A description of an engine which recently came under our notice declares that the parts of the engine are made to "an absolute metric fit." We have seen some metric fits of various kinds, but we do not believe that we would think of putting one of them into an engine.

The Washington Naval Gun Factory—VII

Some Views In the West and South Gun-carriage Shops, Showing the Machining of Gun Slides and Other Work

BY H. J. KENNEDY

The west gun-carriage shop is 366 feet 9 inches long, 65 feet 3 inches wide, and the same hight as the erecting shop; its area is 23,930 square feet. In 1890 the northern half of this was the projectile shop, and the southern half was the forge shop; the manufacture of projectiles at the Washington navy yard has since been discontinued, and a new forge shop has been built south of the quadrangle. The class of work done here is similar to that described in the preceding article, and the accompanying views may be considered as supplementing those already given of the gun-carriage department.

FIG. 45. WEST GUN-CARRIAGE SHOP, LOOKING NORTHWARD

A general view of the west gun-carriage shop, looking northward, is given in Fig. 45. On the extreme left can be seen a portion of a Bement, Miles & Co. slotter, which is shown to a larger scale in Fig. 49. On the right are some Bement-Miles horizontal boring, drilling and milling machines, and in the middle of the picture are numerous small parts of gun carriages, guns, slides, etc.

Finishing Slides for Navy Guns

Fig. 46 is a near view of two Bement, Miles & Co. horizontal boring mills. The first machine has the top table taken off and has on it a recoil slide, the main chamber of which is being bored. This has a base dimension of 24x22 inches, and the length is 5 feet 9 inches. Three tools are being used, taking a ⅜-inch cut with 1/64-inch feed. The farther machine is at work on a similar job.

In Fig. 47 a slide for a 12-inch gun is being faced for the shield, on a Bement, Miles & Co. horizontal boring, drilling and milling machine, of which the table is 8 feet square; it has a head travel of 5 feet and an 8-inch bar, with a bar travel of 7 feet. The machine is using two tools, taking a ⅝-inch cut with 1/16-inch feed, and a cutting speed of 16 feet per minute. The recoil slide is also bored on this machine. The appearance of these steel castings when completed was well shown in Fig. 15 in the second article of this series. There are seven machines like this in the gun-carriage shop.

The operation of boring a 12-inch slide is shown in Fig. 48, being the same machine as shown in the preceding illustration. There are two different diameters of bore, 42 inches and 48½ inches, the 42-inch diameter being bored for a length of 68 inches, and the total length of bore being 112 inches. The cylinders are 15½ inches bore and 39¼ inches long, and the outside diameter of the recoil slide is 52 inches. The head is using five tools, taking a ½-inch cut and having a 1/32-inch feed.

In Fig. 49 a smaller slide is shown undergoing another operation, the slide being for a 6-inch gun and the machine being a 36-inch Bement, Miles & Co. slotter with a 5-foot table and travels of 24 inches and 24 inches, and a rotary feed; it is taking a 1¼-inch cut with a feed of 1/32 inch, the cutting speed being 15 feet per minute.

The South Gun-carriage Shop

The quadrangle is completed by the south gun-carriage shop, which is 186 feet long, the same width as the west shop, and 40 feet high, its area being 12,137 square feet. Its general appearance is shown in Fig. 50. At the right the trunnion of a slide for a 12-inch gun is being trued on a Bement, Miles & Co. horizontal boring, milling and drilling machine, which has a table 8 feet square and elevation of head of 5 feet, and has an 8-inch bar with a travel of 7 feet. On this gun slide, as well as on some of the 12-inch slides in the foreground, can be plainly seen the seat for the shield, which is being machined in Fig. 47. On the left is

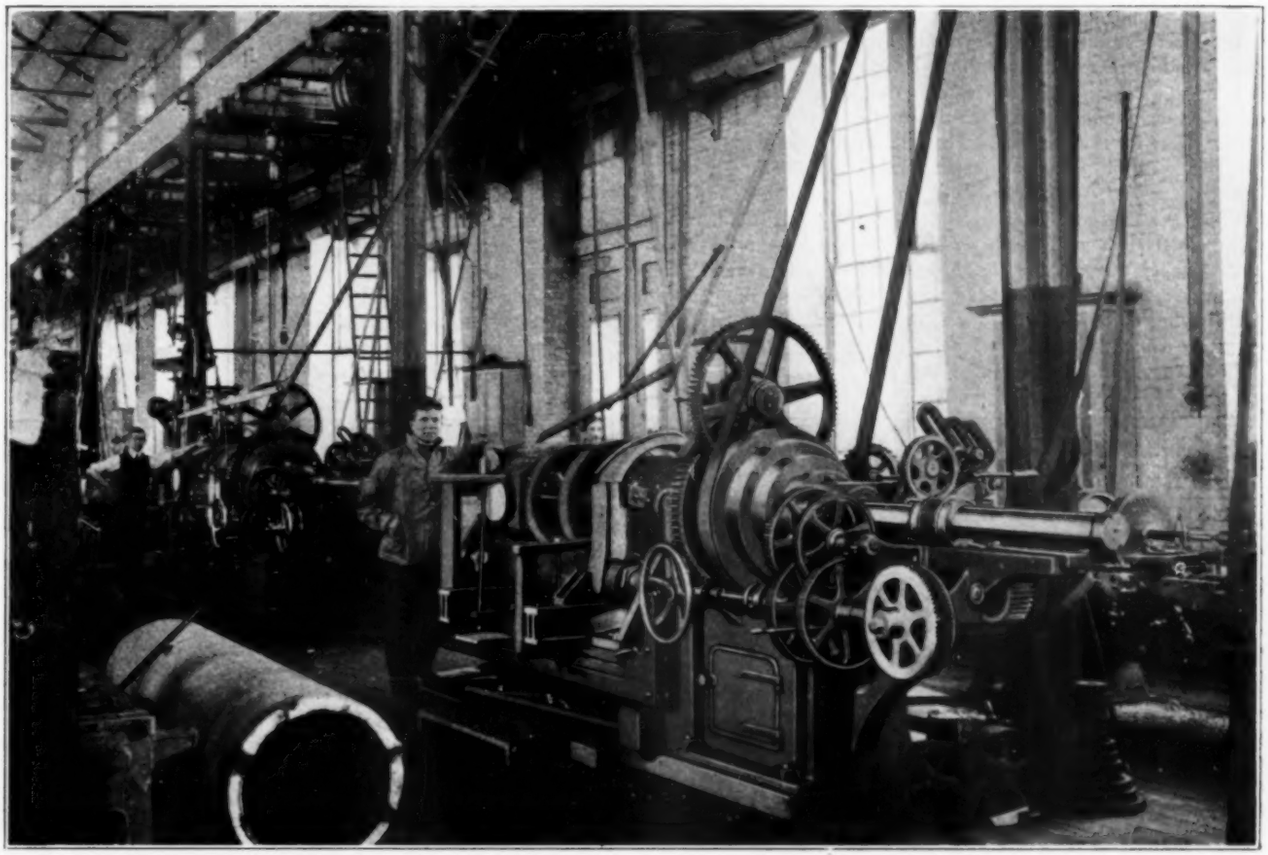


FIG. 46. BORING GUN SLIDES

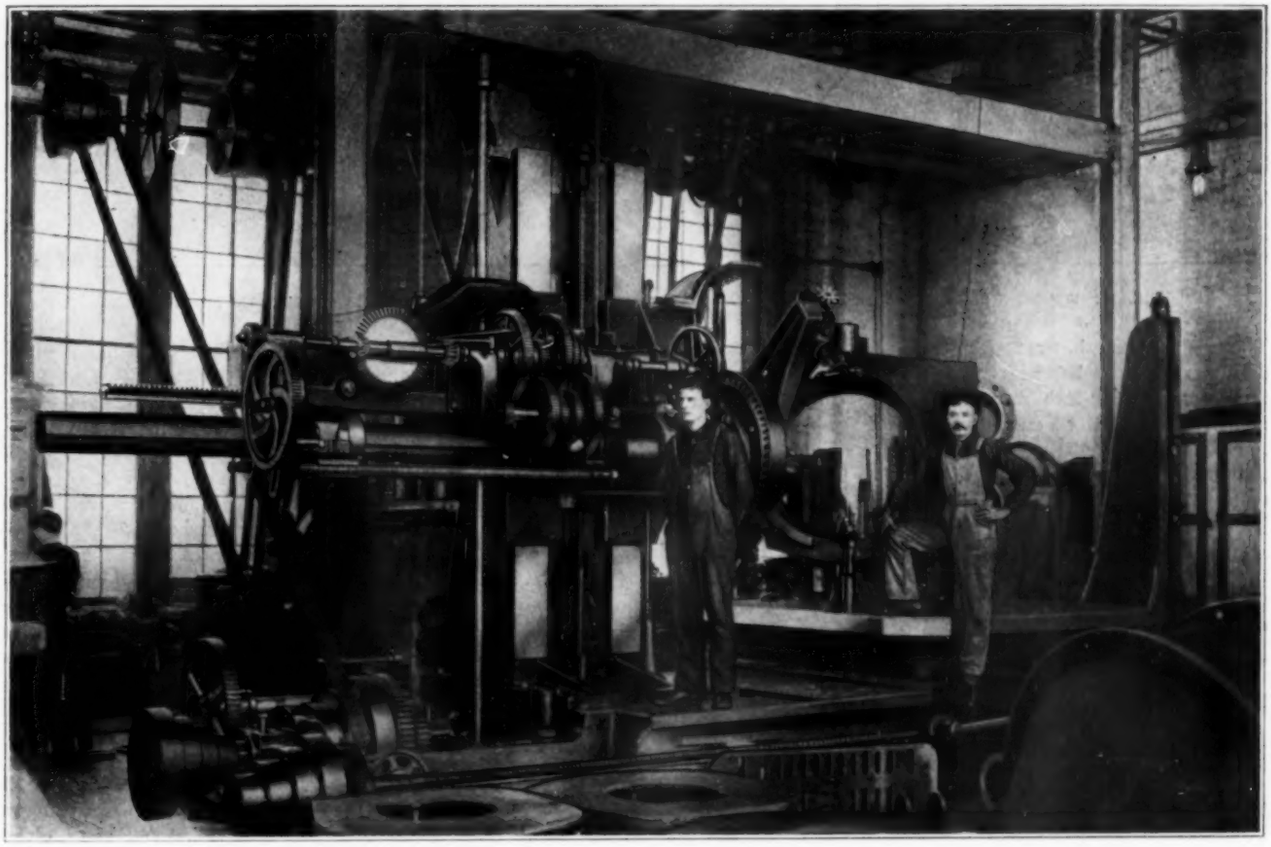


FIG. 47. FACING AN OBLIQUE SURFACE ON A GUN SLIDE

a battery of boring and turning mills, of which a larger illustration is given in Fig. 51. In the extreme background at the left side of the shop is the horizontal boring, drilling and milling machine which was illustrated in Figs. 47 and 48. The one on the right of Fig. 50 has the same dimensions.

Fig. 51 is a near view of the boring mills illustrated in Fig. 50, which are Pond make, the one in the foreground having a 12-foot table and swinging 13 feet, having an 8½-inch ram, with a travel of 5 feet 6 inches. This machine is turning and boring the yoke for an 8-inch gun.

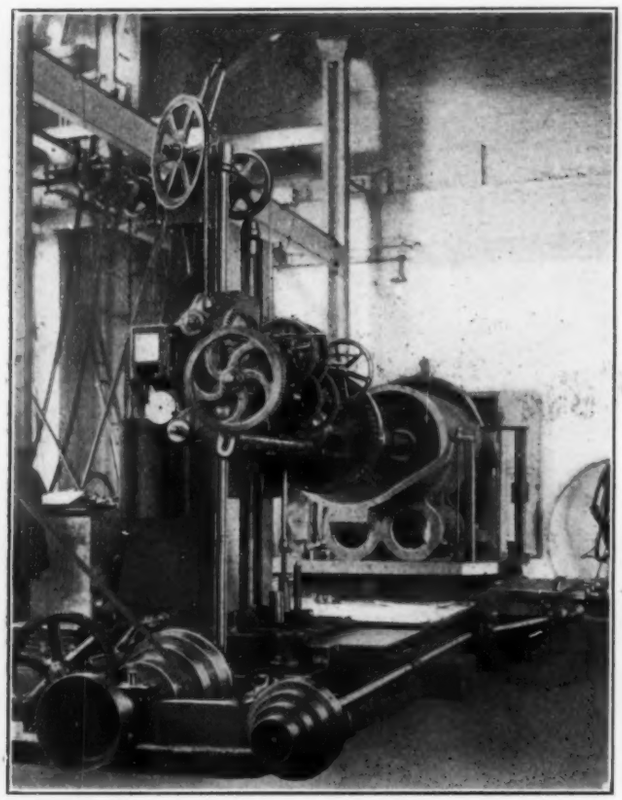


FIG. 48. BORING A SLIDE FOR A 12-INCH GUN

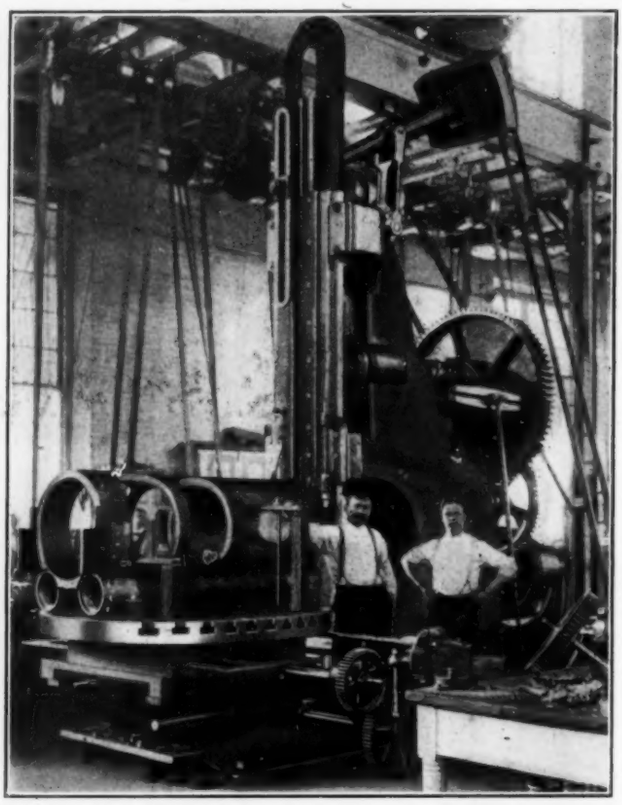


FIG. 49. A SIX-INCH SLIDE IN THE SLOTTER

The next machine has a 10-foot table and swings 11 feet; it has an elevation of 62 inches and an 8⅛-inch ram, traveling 62 inches. It is at work on four steel castings known as elevating arcs, which are put together on the table of the machine to form a circle; they are for 6-inch guns. There are two tools in action, taking a ⅛-inch cut with a feed of 1/32 inch. The next machine is also a Pond, with an 8-foot table swinging 8 feet 8 inches, an elevation of 52 inches and a ram travel of 48 inches. It is at work on the cast-steel recoil slide for a 4-inch gun, which is having its trunnion turned off. This casting is 24x22 inches by 4 feet 1 inch long. In the extreme background is the Bement, Miles & Co. horizontal boring, drilling and milling machine which has already been referred to as illustrated in Figs. 47, 48 and 50.

In Fig. 52 we see a Bement, Miles & Co. horizontal boring, drilling and milling machine boring the recoil slide for an 8-inch gun. This machine has an 8-foot table, a head travel of 5 feet, table travels of 5 feet and 9 feet, and an 8-inch bar with a travel of 7 feet. The recoil slide is a steel casting, the large bore of which is 33 inches, the small bore 29 inches, the length 84 inches, the outside diameter 34 inches at the small end and 47 inches at the large end. There are three tools in action taking a ½-inch chip with a 0.02-inch feed.

As illustrated in Fig. 53, some work is done in the gun-carriage shop besides that directly associated with guns and mounts: the job shown here is the boring of the outer casing for an 18-inch submerged torpedo tube, with an 8-inch bar of a Bement, Miles & Co. horizontal boring, drilling and milling machine; the diameter of bore is 26¼ inches, and the length 7 feet 6.95 inches. The machine has a table 8 feet 2 inches, and a bar travel of 5 feet 6 inches. There are three tools in action taking a light cut.

The Kobbe Company, publisher of *Compressed Air*, announces the removal of its offices from 90-92 West Broadway to 108 Fulton street, New York City. The growth of that journal and the fact that quarters had to be found for the new men being added to its staff necessitated the removal to more commodious offices, where further expansion could be provided for.

Variable Cutting Speeds versus High-speed Returns as Applied to Metal Planers

By W. S. Hagaman

During the last few years there have been many changes in the design of almost all kinds of machine tools, but it was some time before the reciprocating machines were seemingly considered. In this class of tool much time is consumed by the "return" stroke, and therefore it would seem that to increase the rate of return would add largely to the output of the machine.

Let us consider the metal planer of a common size, 36 inches. The ordinary machine of this size is usually designed to have a cutting speed of about 20 feet per minute and a return of 80 feet. One planer manufacturer is providing a high return of about 150 feet per minute—in fact, a well known concern built planers some years ago with a return ratio of about 8 to 1. Several other concerns are now furnishing various rates of cutting speeds, but are providing only a moderate rate of return. The prospective purchaser is interested to know which type of construction is the most efficient, economical, durable, etc., or in other words, which is the better investment. As work done and time saved, as well as money invested, must necessarily be considered, a few figures may be

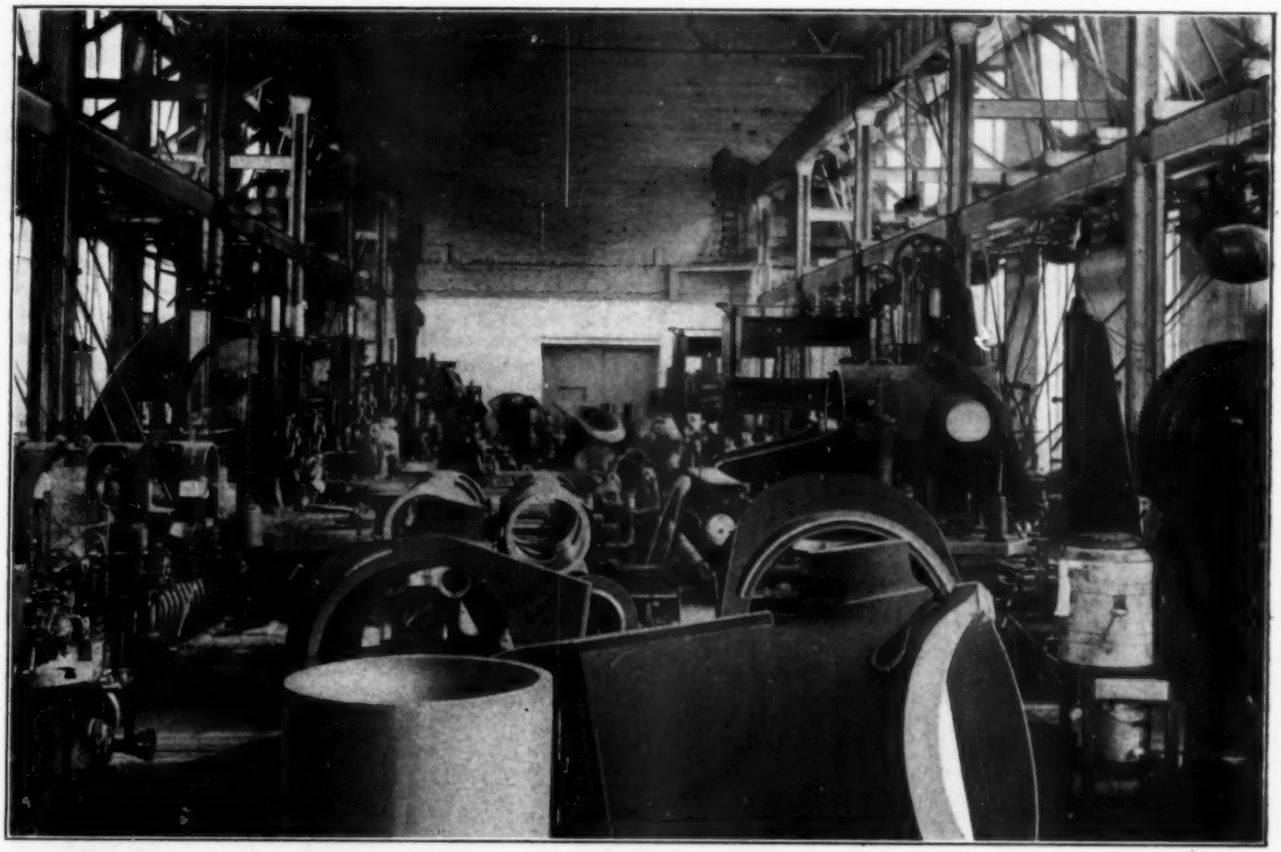


FIG. 50. SOUTH GUN-CARRIAGE SHOP

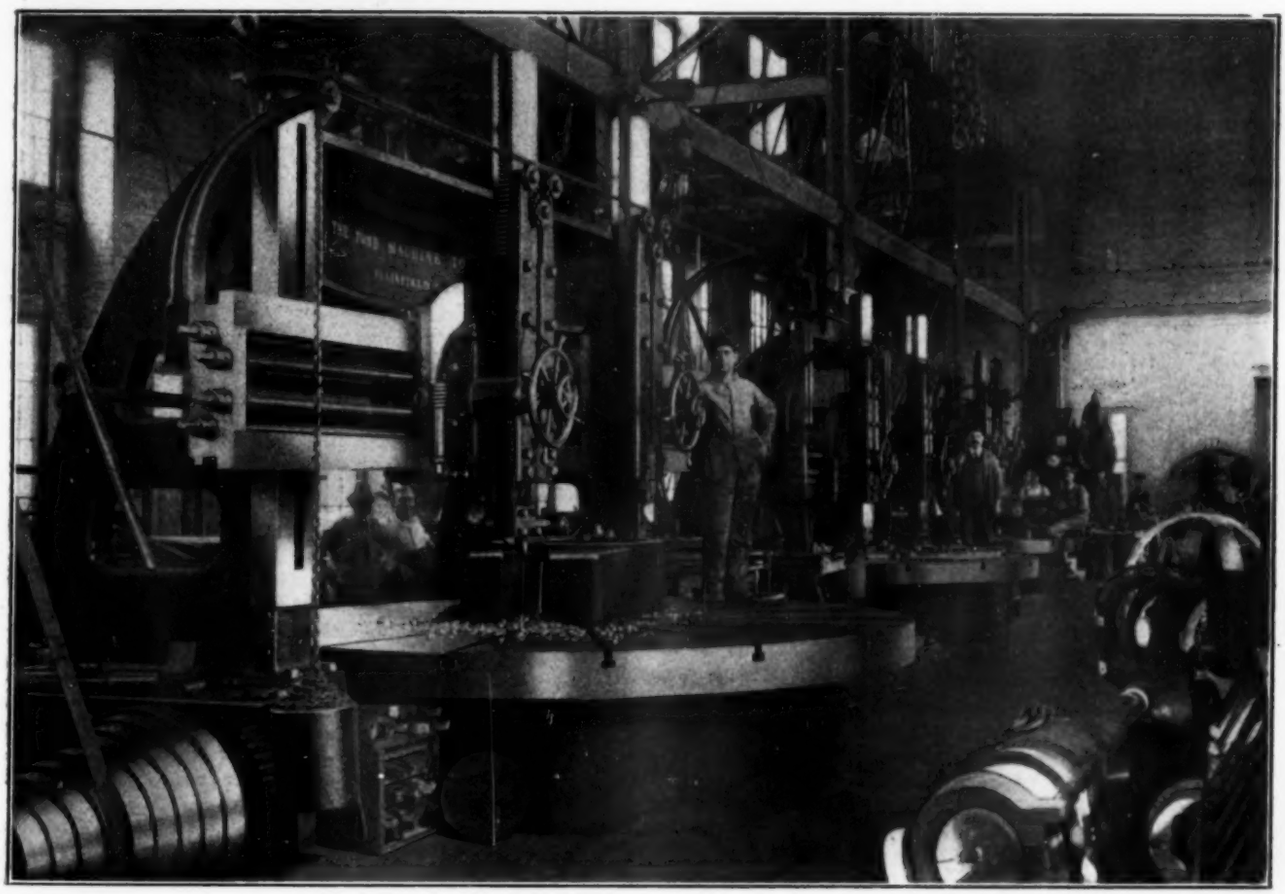


FIG. 51. FINISHING AN 8-INCH GUN YOKE, AND OTHER WORK

of interest and service. So we compare the gain secured by increasing the cutting speed with that obtained by increasing the return speed; let us assume the following speeds for consideration.

TABLE 1

Cutting Speeds.	Return Speeds.	Cutting Feet per Hour.	Gain.
Feet.	Feet.	Feet.	Per Cent.
20	80	940	....
40	80	1,600	66⅔
20	160	1,066⅔	11.1

It will be seen that, with the speeds assumed, doubling the cutting speed increases the cutting feet per hour, or, we may say, the productive capacity of the machine, 66⅔ per cent., while doubling the return gives an increase of only a trifle over 11 per cent. Therefore doubling the cut is the more profitable by about 55 per cent.

Nearly all other machine tools are provided with several cutting speeds, but the planer has only quite recently been improved in this respect. As doubling the return gives an increase of only about 11 per cent., to see what increase may be secured by having several rates of cutting speeds, as are now being furnished by several well known manufacturers, let us assume the following:

TABLE 2

Cutting Speeds.	Return Speeds.	Cutting Feet per Hour.	Gain.
Feet.	Feet.	Feet.	Per Cent.
30	80	1,308	....
40	80	1,600	22.3
50	80	1,845	41
60	80	2,056	57.1

From the above it will be seen that very material gains are secured by changes in the cutting speed and that these gains are far in excess of anything that can be secured by using even a very high rate of return.

Different operations, such as roughing and finishing, as well as various kinds of material, require different cutting speeds as every mechanic knows, and it would seem, therefore, that providing a suitable variety of cutting speeds is of far more value to the planer user than quick return speeds. Some manufacturers provide two cutting speeds, one of which must be low enough for hard materials and the other is usually quite high. There are a great many cases where the intermediate speeds are of the utmost value, as they can be used where the low speed is too low and the other too high. The operator is thus obliged, with the two-speed type of planer, to machine his work at the lower speed, whereas if several speeds were at his command, such as are shown in Table 2, a very material gain in output would result.

Note—It will be observed that the cutting speeds in Table 2 are higher that those in Table 1; these speeds, however, are practical and can be had from builders of first-class machines, if so desired.

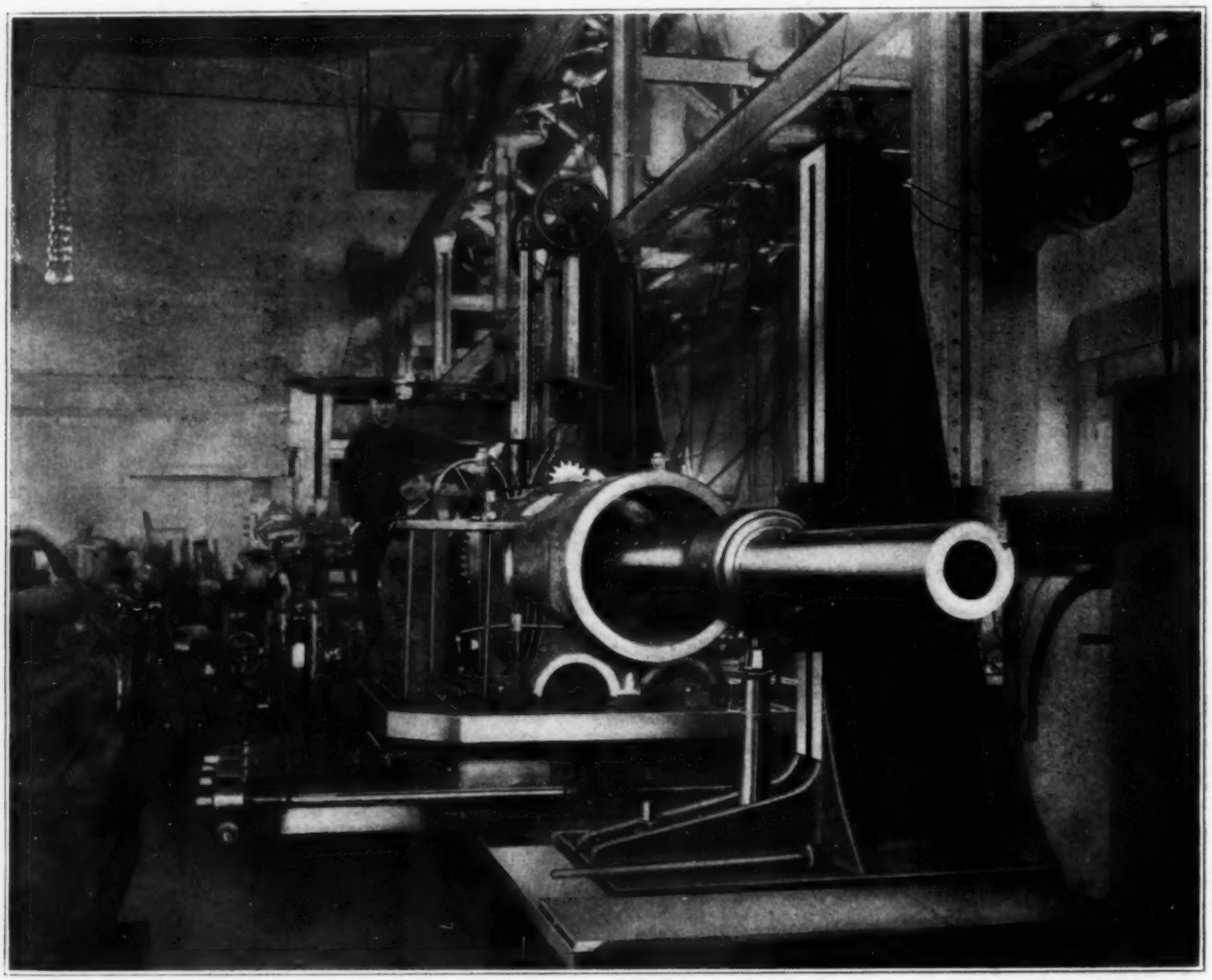


FIG. 52. BORING AN 8-INCH GUN SLIDE

One of the features connected with the automobile show that stands out in bold relief is the "Hyatt Annual" given by the Hyatt Roller Bearing Company in the Astor Gallery of the Waldorf-Astoria. Plenty of refreshments of all kinds were there to eliminate all friction, and there was a good vaudeville entertainment leading to a very enjoyable evening.

Shortcomings of Handy Men in Literary Workshops from the Standpoint of a Machinist

By W. Osborne

When I read the editorial on page 228, it filled me with hope. The professor is human like the rest of us and some of his work needs polishing. I send out a corn sheller and think it very complete until someone howls about some of the details or the finish not being right. As I am trying to beguile others to buy corn shellers I listen to the howl and try to remove the cause, for I do not want to get a chorus of that kind started. It carries too far. Once we put cast iron in a place we afterward found had to be filled by steel.

Now, the professor writes a book. He is the designer. The brain work is his. Various other people carry out the petty details, as they do with my corn sheller. This book is the professor's corn sheller, so to speak. I am using several of these intellectual corn shellers and I would like, for a minute or two, to get hold of some of the handy men who have been broken in on the symbol machine. They should be made to put in more time with the consumer before they are put on important jobs.

I realize, now, the position of the professor. In giving expression to the labors of his mind he may not use the exact terms that will convey the meaning in the clearest manner to those to whom it goes. That is the duty of the shop man: he should know how to get the ideas into the head of the reader, regardless of the form in which the professor conveyed them to him.

I want to show that the literary shop man is not onto his job in the conveying line. He neglects his work in a shameful manner, and tries to throw it off on the general public in a way that cannot fail to react on the interests of his boss. Perhaps you think this is merely assertion and would like some proof before believing it. Now listen.

One man, in a book on belts that is intended for belt users, in translating his boss's ideas uses Σ for addition, Δ for subtraction, ϕ, θ, and α for designating angles (and the latter one is used in three entirely different ways without distinguishing marks), ϕ for the co-efficient of friction, σ for thickness, σ^1 for diameter, which makes the square of the diameter look like this: σ^{12}. H with a circle around it is used for something, but my digging tools gave out before I uncovered its significance. These do not exhaust the list by any means. Generally diligent search will show what these mysterious marks stand for, but it is not always safe to assume that you know what they stand for in one part of the book because you know what they stand for in another part of it.

In another book that was but recently put on the market, and that in type and press work is above reproach and a credit to the publishers, I find some symbols that are new. The meaning to be assigned to some of them is given. It can be presumed with tolerable safety for others, by one who has a reasonable familiarity with the subject, but even a man skilled in guessing and used to extracting information by means of an ax and a crowbar has not as yet been able to get at the meaning of many of them.

I can readily understand that these things form part of a system of educational shorthand, very convenient to both professor and students in their work, and it was very natural for the professor to use it when he wrote the book; but the trouble is that the man who did the common shop work deserves to be "fired." His part of the work is a disgrace. He should have known that, big as that college is, all the world did not go to school there. In justice to this man though, it may be that the publishers did not tell him that this book was being got out and advertised for sale to the general public as a book for reference on this particular subject, and in that case it is not his fault, but theirs.

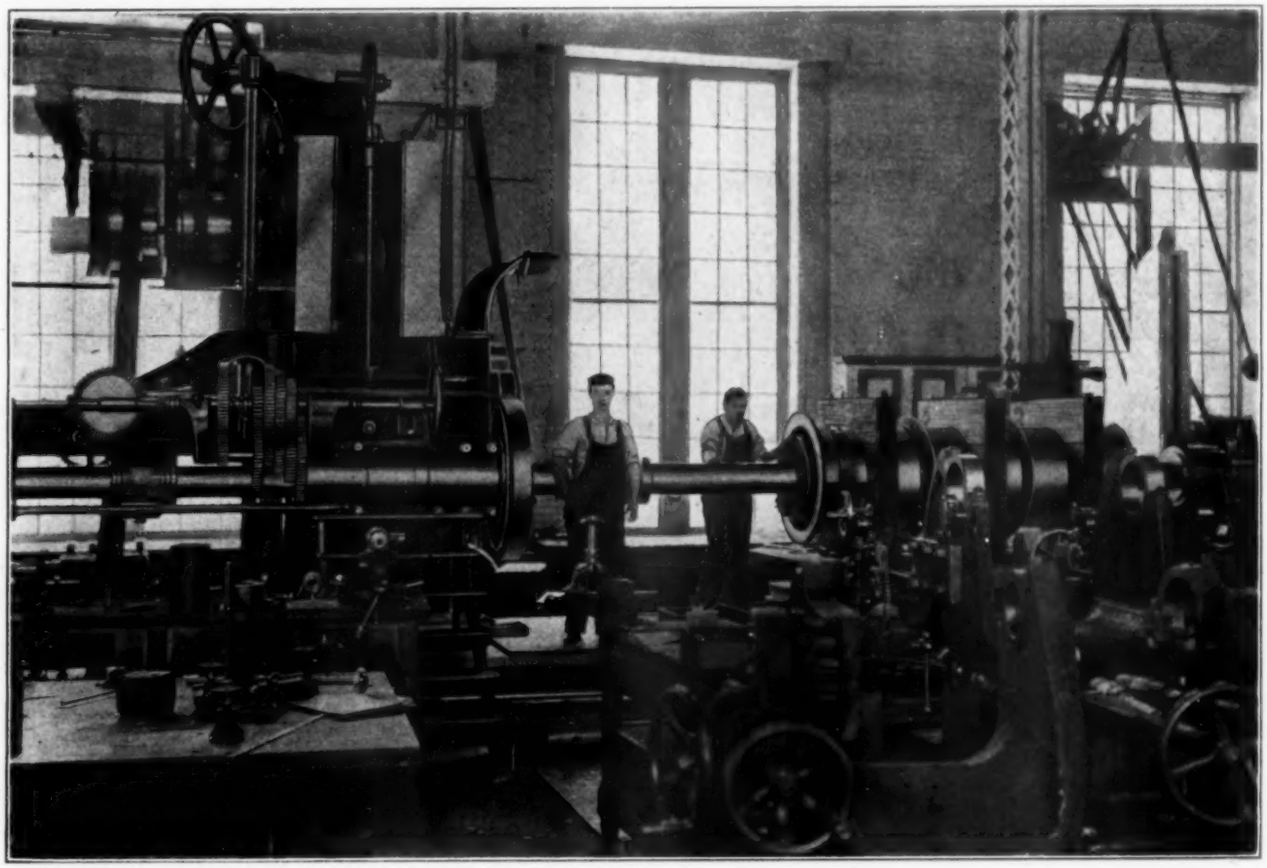


FIG. 53. BORING THE CASING FOR A TORPEDO TUBE

The professor in this case did a good job on his designing in getting up this book. Every idea that I have been able to get from it has been a good one, but after I have spent two hours and nineteen minutes of hard work in trying to get at the meaning of a symbol that is the key of what may be another valuable idea, and that without success, I have felt that my confidence in that publishing house has been shaken. If I sent them a corn sheller that would not shell corn they would send it back and demand one that would, or else demand the parts necessary to make it complete, and that is what I should like to do in this case. My customers do not want to have to rebuild my machine before they can use it, and neither do I want to have to take a course in the particular college to which the professor is attached before I can read his book. If that was the intention, the publishers have no right to deluge the country with advertisements of it as they now do. Under the circumstances, they should at least publish a key with any further editions, and let it be known that it could be purchased by present owners of the book. A firm that has such a book for the use of its employees can well afford to pay almost any price for a key as a time-saving proposition.

Some broad-minded philanthropist should make arrangements whereby the publishers, or whoever are responsible for the present condition of affairs, can be given a short course in the art of digging out information without a college education.

A Modern Foundation for Heavy Tools

We are indebted to C. H. Norton, of the Norton Grinding Company, Worcester, Mass., for photographs and data regarding their system of putting in foundations for heavy tools, such as planers, milling machines, and other tools requiring accuracy.

The feet of a planer, or other tool, rest directly on what is called the adjusting plate which comes between the machine and the foundation proper.

Ten of these adjusting plates are shown in place on the foundation for a new planer. This foundation is of one solid concrete block 5 feet deep. The concrete is filled to within 8 or 10 inches of the floor, as shown, and the adjusting plates are located in their proper positions to receive the feet of the new machine. The four screws in each plate allow a very fine adjustment. They are tested with a 15-foot Brown & Sharpe straight-edge until tissue paper will hold tightly under all of them, when the straight-edge is passed from one of the adjusting plates to the other. When they have been adjusted to the desired accuracy, concrete is filled in around them as shown in Fig. 2, practically to the level of the top of the plates, but with space to get at the screws for adjustment when necessary.

Figs. 1 and 2 do not show the same foundation, that in the latter being for a large Beaman & Smith milling machine.

After the machine is in place, castings are made for covers to the openings over the screws to keep the chips out of them. These can be removed at any time and the plates raised or lowered a fraction of a thousandth, by the movement of the wedge. A slight adjustment of these wedges will spring the bed of a planer or milling machine so as to make it plane or mill perfectly straight, either when new or after it has become worn.

The construction of this adjusting plate is shown in Fig. 3. First comes the main casting underneath, which is made very heavy and has a stiff truss running underneath it to prevent springing when the opposing screws are tightened up. The surfaces of the truss, of the wedge, and of the plate are all planed, and the wedge is guided along the truss by the customary spline and groove. The plate fits the entire surface of the wedge and graphite is used between them in putting together, so as to allow steady movement when necessary. The ends of the plate are also planed to fit between the ends of the main casting so as to prevent any lost motion.

As an example of the efficiency of this foundation, Mr. Norton cites an instance of an 18-foot by 36-inch planer mounted in this manner that has been in use about a year, yet is so true that when the 15-foot straight-edge is placed on tissue paper at any three points on the table, they will all be tight, and this regardless of the position of the table on the bed. He suggests that anyone using the ordinary

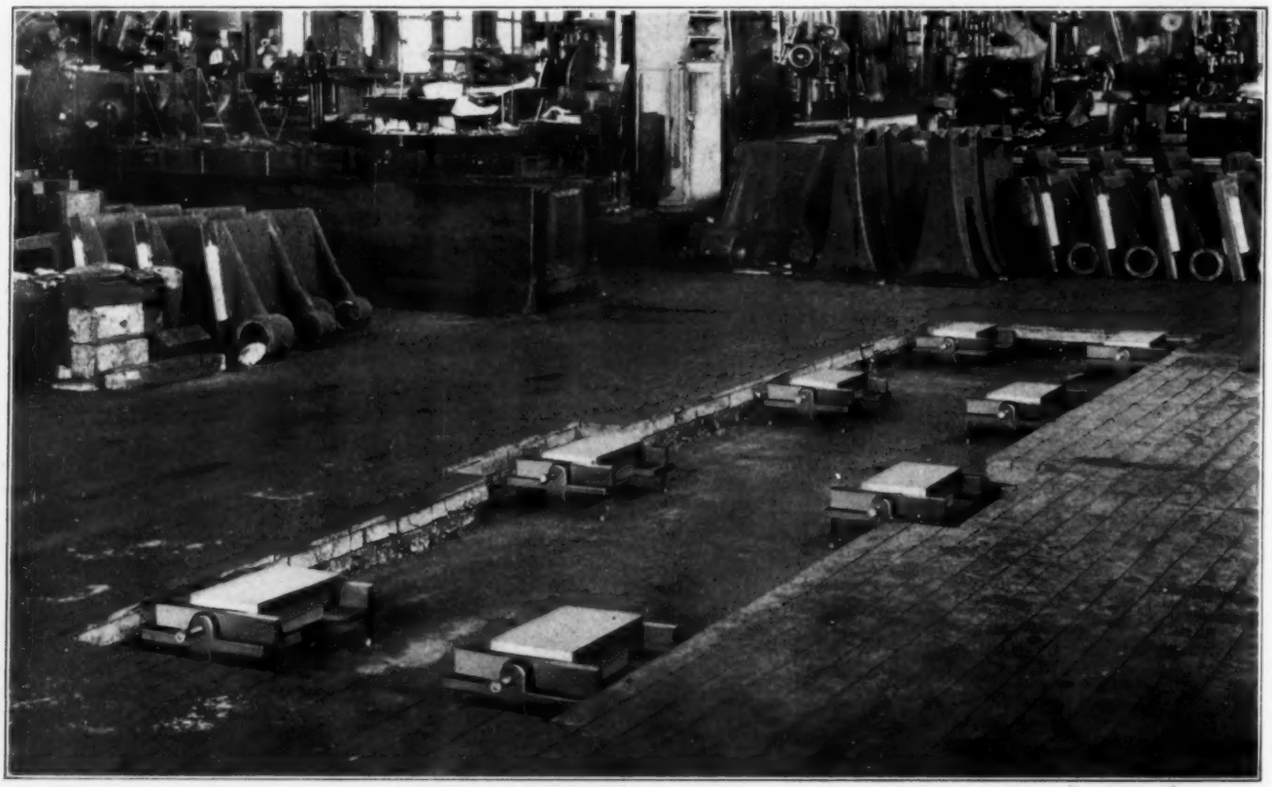


FIG. 1. PLATES LEVELED UPON CONCRETE FOUNDATION FOR A PLANER

foundation should try a similar experiment, and is inclined to believe that he will be surprised at the inaccuracy he finds, especially with the table at different points along the bed.

A solid concrete foundation and good leveling devices make it possible to secure a degree of accuracy in the planer that has hitherto been considered impractical, and it is a great aid to accurate work of any kind, especially grinding. While these foundations are somewhat expensive, Mr. Norton is using them for all his heavy tools, and in addition to the increased accuracy of the work secured, there is a great reduction in the amount of scraping necessary to get and to keep the tools in prime condition.

Another interesting feature brought out in this connection is the fact that they do not find it necessary to bolt planers to the foundation at all. Their practice is to drill into the plates and put in a half-inch pin at each side of one or more pairs of planer feet to prevent sliding endwise; but it has been found that, in cases where these pins do not quite touch the feet when first put down, the planer never moves enough to touch them. This is especially interesting because most if not all of us have always thought it necessary to bolt planers solidly to the foundation; but, as Mr. Norton says, when we come to think of it, why should they be bolted down at all? A modern planer, if it is heavy enough to be of service, cannot be moved by the reversal, and the belt pull will have no effect on it.

Motor-driven Machines at the Chicago Electrical Exposition

The wide-spread application of the electric motor, and the superseding by it of hand power for small machines, even down to 1/25 horse-power, were well illustrated at the recent Electrical Trades Exposition in Chicago. In the Westinghouse exhibit alone there were over 20 machines of various types, each driven by a suitable motor. The electric current is now coming to mean something more in the home than merely a source of light; for instance, the exhibit included a motor-driven washing machine, an ironing machine, a sewing machine, and a sanitary cleaning and scrubbing outfit; the latter attracted much attention by its ability to remove quantities of dust and dirt from apparently clean rugs, clothes, upholstery, etc. The applications of electric motors which have now become common in shops and manufactories were also shown.

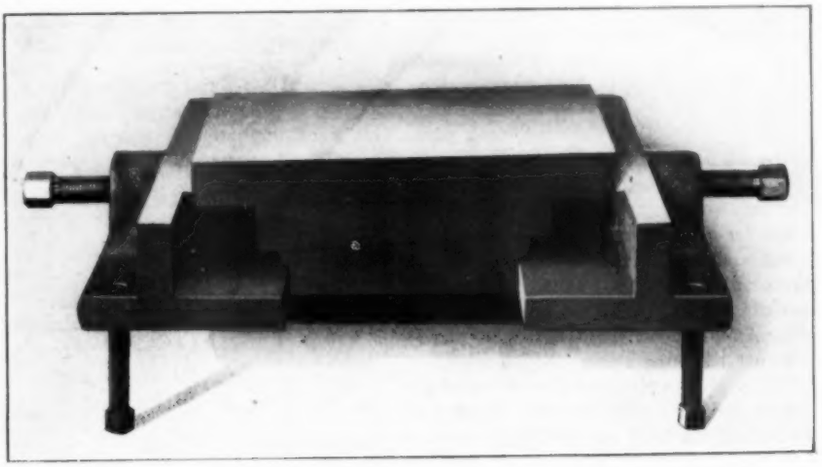


FIG. 3. ADJUSTABLE PLATE FOR FOUNDATION

In these days of "simplified" as well as complicated spelling, there seems to be no reason for "carboretor," which appears in a catalog received some time ago. This makes the fifth spelling for the device intended. No wonder the perfection of a carbureter is such slow work!—*The Gas Engine.*

FIG. 2. CONCRETE FILLED IN AROUND PLATES, LEAVING OPENINGS FOR SCREWS

CORRESPONDENCE

Discussing Phases of Machine Design and Construction

A Slotting Attachment for the Screw Machine

The sketches show a special fixture for use on an ordinary capstan or turret machine for slotting screws without handling them a second time. The tools required are easily made and the method insures a perfect slot in all screws, the work being done "automatically" in the operation of the turret head.

Fig. 1 gives a plan and front view of the turret and slide, and shows the means of operating the tools for holding the screw after it is cut off and while it is being slotted. The screw-holding chuck is shown in section in Fig. 2. This tool is made of mild steel, the stem *A* being fitted to the hole in the turret. The front end of the shank is bored out for the nut *B* and threaded on the outside to fit the body *C*, which is screwed tight to the shoulder. The body is bored out to take the spring chuck *D*, which is closed by a helical spring abutting against the nut *B* screwed onto the end of the chuck. The chuck is opened by the lever *E* coming in contact with a stop on the cross slide while the screw is being cut off. In the section the chuck is shown open with the spring compressed; when the turret is drawn back the spring closes the chuck, and the screw is held and carried around with the turret until the latter is indexed half way around, when it is in slotting position, as indicated at *F*, Fig. 1.

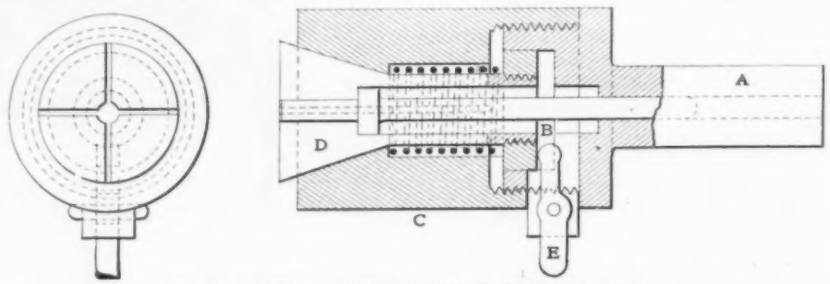


FIG. 2. SHOWING CONSTRUCTION OF SPECIAL CHUCK

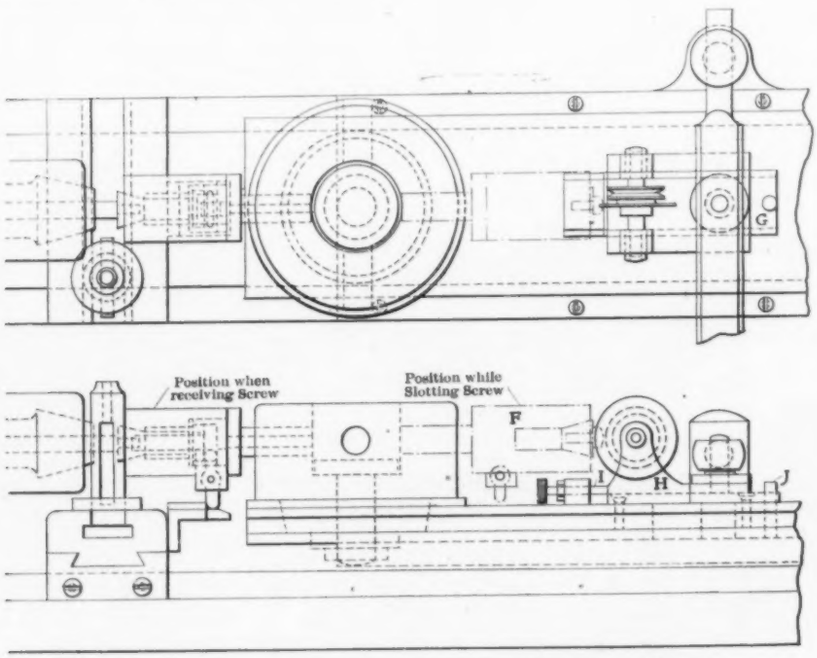


FIG. 1. SCREW MACHINE FITTED WITH SLOTTING ATTACHMENT

A dovetailed piece of iron *G* is fixed to the turret slide by screws, and on this is a cast-iron slide *H* which carries the saw spindle. This spindle is driven by a round belt passing over a grooved pulley on a small countershaft; the travel of the slide is not enough on ordinary screw work to affect the drive. The stud usually used to pivot the lever which operates the turret slide is taken out and another stud is fitted in the slide *H*. In slotting the screw, the main turret slide is tight enough so that in operating the lever the saw is first brought up until it slots the screw the required depth. Then, the spindle slide *H* being against the adjustable stop *I*, the whole slide is moved forward in the ordinary way. When the slide is drawn back, the saw is withdrawn until slide *H* comes in contact with the stop-pin *J*, when the main slide is drawn back. The special chuck for holding the screw should be made longer than the other tools, so that these will clear the saw, as the movement of the latter is the same on each stroke of the turret slide.

The screw holder is provided with an ejector, and when the screw is clear of the saw a trip opens the chuck as the turret swings round and the screw is thrown out and into a box. The tripping device is not shown, but consists of a cam piece fixed on the turret slide. As there is a chance of long screws being chafed by the inner end of the spring chuck, the chuck should be opened out at the back, leaving about ¼ inch of bearing surface by which to hold the work. The spindle brackets of slide *H* are fitted with threaded bushes hardened and slotted. By adjusting these endwise the saw can always be set central to the holder and the end play also taken up.

C. PETITJEAN.

London, Eng.

Small Punches That Stand Up on Heavy Work

A few days ago I happened into a little shop in the neighborhood where much punching is done. One of the things that struck me was the construction of the small punches they had in use.

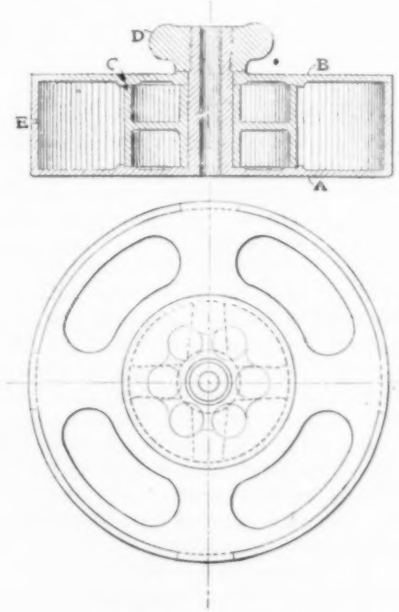
They use cold-rolled steel rod for the shank of the punch. The rod is about 5/16 inch in diameter drilled lengthways to take a piece of Stub steel. The top end of the hole is countersunk, and the

Stub-steel punch is riveted over to prevent its pulling out.

I should judge that the Stub steel was about No. 40 or a little smaller, and they were punching iron a full 1/16 inch thick. The shank is held in the press with set screws in the usual manner. They said the punches were cheaper and more satisfactory than those they previously used, which had the punch and shank in one piece. A. G. KNIGHT.

A Music-wire Holder

In connection with the articles which have appeared from time to time describing various methods of coiling springs, I do not recollect seeing anything regarding a suitable reel or holder for the coil of wire. Anyone who has attempted to coil springs, from music wire especially, has encountered the difficulty of holding the coil satisfactorily.



A MUSIC-WIRE HOLDER

During a recent visit to a modern shop the writer witnessed the coiling of some music-wire springs by an operator, assisted by two boys. The latter were engaged in uncoiling the wire and guiding it to the operator. The coil of wire was indifferently held by a crude wooden reel. This has induced the description of a holder which is being used with great satisfaction and economy.

Referring to the drawing, it will be seen that the holder consists of a circular box of cast iron. There are four pieces: the box *A*, cover *B*, spider or center *C* and the nut *D*. In fitting up the castings, the box *A* is chucked in the lathe with the open side out. The stem is turned, threaded, a hole drilled entirely through the center, and the seat faced for the spider. The cover *B* is chucked, bored and the spider seat faced. The spider is chucked, bored to fit the stem, driven on a mandrel, and the outside turned and the ends faced off the thickness required. The nut is chucked, bored, faced and tapped. The four lugs on the cover are just cast a loose fit for the notches in the edge of the box.

It may seem from the foregoing decription of the operations required that the labor cost would be high, but actually a good lathe hand will make short work of it.

Now regarding the use of the box. The nut and cover being removed, an uncut coil of wire is placed within and the outside end of the wire is drawn through the hole *E*, which is considerably larger than the wire. The cover is replaced and the nut screwed down. Through the openings in the sides the bonds are cut and the device is ready to use. It may be conveniently supported by a peg inserted in the central hole, or by any other suitable means.

It is best to have a holder for each size wire in use, the size being plainly indicated on the outside. The wire will draw out freely without kinks to the end of the coil. It is advisable not to attempt to remove the cover while an unbound coil is inside. I believe the credit for conceiving and designing this is due to George Sponable, superintendent of the C. E. Lipe estate, Syracuse, N. Y.

H. D. POMEROY.

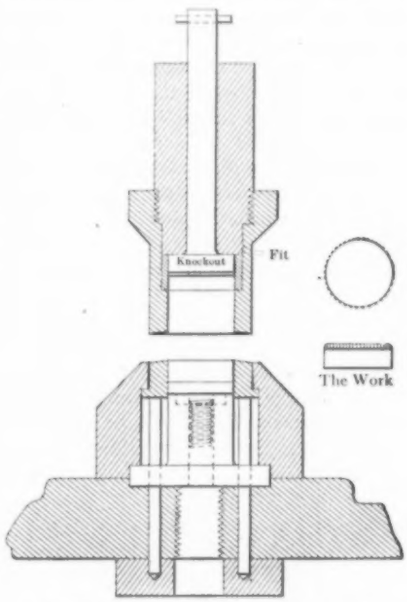
Drilling a 2¾-inch Hole Through Glass

Having to cut a 2¾-inch hole through a round piece of glass 12 inches in diameter, we proceeded as follows. We intended to use a piece of brass or copper tubing 2¾ inches diameter on the outside, but not having any that size we turned up a wooden plug 29/16 inches diameter and 4 inches long. We bent a piece of 1/16-inch sheet copper around this plug and fastened it so that the copper projected over the end about 3/16 inch. We flattened out the shank of a broken bit and drove it into the plug. Through a board 16 inches long and ¾ inch thick a hole was bored just large enough to permit the plug to turn in it; the glass was then fastened to the board concentric with the hole with short nails.

With No. 60 emery and turpentine we began to cut the hole, using the board as a guide for the plug and with a brace to turn it. This worked fairly well, but when we used the emery dry better progress was made. Of course we neither bore down hard, nor turned fast, as we did not want to generate any heat and crack the plate. The plate was cut through in about one hour's time. BERNARD W. NOEL.

A Single-action Blanking, Drawing, Nurling and Embossing Die

Nurled cups are used on a great many articles in the tinware line, from small half-inch sample boxes to rather large screw caps, and in quite a variety of forms. Usually the caps are nurled in the trimming machines, but when trimming is unnecessary they can be produced much more cheaply by the single-action combination blanking, drawing, nurling and, if necessary, embossing die shown in the sketch, the general type being quite well known. The nurls were made separate, so as to be easily replaced when worn or broken. The male is held down to the drawing block by a flat-head screw and the female is made long enough to permit reversing, thus securing double service at a slight additional cost in the making. The cutting of the nurls was very simple, being finished completely in the lathe. The large cone gear, having about a hundred teeth, was used as an index. A piece of ⅜x1½-inch iron, clamped to the ways so as to spring from tooth to tooth, acted as a stop. The tool used was only a piece of ⅝-inch square steel, given an eighth twist, or ground that way, set level with the centers and ground at an angle of about 75 degrees.



A SINGLE-ACTING BLANKING, DRAWING, NURLING AND EMBOSSING DIE

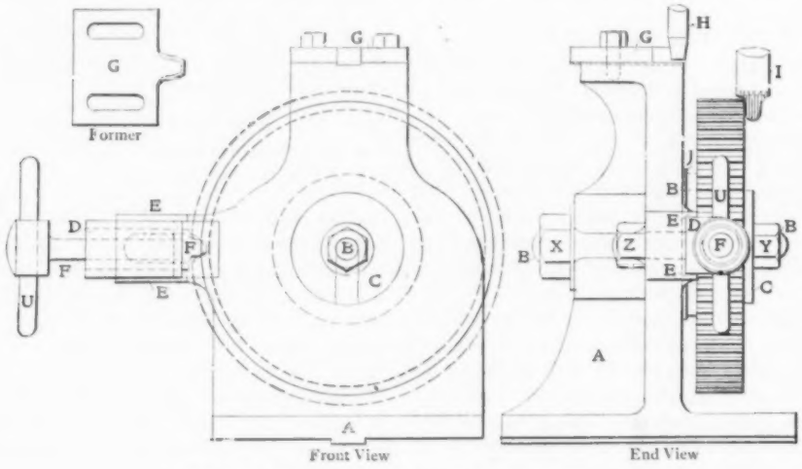
Thus prepared, the cone and back gears were both thrown out of gear, leaving the chuck and work easily revolved from tooth to tooth by hand. The carriage is also easily reciprocated by the other hand. The cut being s[illegible]ight, no bother was taken to back off the tool after each cut, and three or four revolutions of the work made a smooth job. The time was only about an hour or so [illegible] each, including

rigging up; of course, a small rounding is put on each to prevent cutting instead of forcing the metal where it belongs. The length of the nurl is regulated by the depth the punch enters. Plain caps can be run, or the male nurl can be fastened from below and a design or letters embossed on top, using the knock-out plunger as a force. The bevel edge permits the die-setter to upset the punch quite often before refitting, and the combination is inexpensive to maintain. SIRIUS.

Rounding the Edges of Gear Wheel Teeth

The sketches show a fixture for rounding the edges of gear teeth used in automobile change-speed gears. This allows the gears to engage more easily while they are in motion, which they will not do if left square at the ends from the gear cutter. The fixture is used on the table of a profiling machine, can be operated by a boy, and effects very great economy as compared with chipping and filing.

A is a gray-iron ribbed bracket planed on the bottom to suit the T-slots in the table and bored out in the center to receive the arbor *B*, which has a collar ¼ inch thick at the front side of *A*, as shown in the end elevation, against the projecting boss *J* which is faced. This is held by the nut *X* at the back. *C* is a slip washer for holding the work securely in position, by the nut *Y*. *D* is a steel sleeve bored out to receive a spring plunger *F*, which is shaped on the front end to fit the teeth of the gear being operated upon. It is held in position by the nut *Z*, operating on the screwed shank of *D*, which passes through the slot, shown dotted, drilled through *E*, which is a projecting lug cast solid with *A*, and planed out to receive *D* as shown.



FIXTURE FOR ROUNDING EDGES OF GEAR TEETH

The top of the bracket *A* is planed to receive the formers *G*, which are interchangeable to suit different pitches of gears and are held on by the two set-screws, passing through slot holes in the former for adjustment. *H* shows the former peg as it follows the path of the former, and *I* shows the cutter which is made out of a steel bar ½ inch diameter, with the cutting edges milled on the formed part at the bottom end, as shown.

When the nut *Y* is slackened the slip or open side washer *C* is taken off; the wheel can then be slipped on the mandrel or arbor, being large enough in the bore to pass over *Y*. The spring plunger *F* is then pulled back by the handle *U* and the whole wheel pushed up against the collar *B*. *F* is then inserted in a space in the teeth to hold it in place, *Y* is tightened up, and the work is secured. The former *G* is then adjusted to suit the former peg *H*, which is carried on a bracket attached to the machine, and the cutter *I* is brought into operation. By operating the two handles for the compound movement of the table, and keeping the peg *H* tight up against the former *G*, the cutter is made to follow a similar path and put a radius on the edges of the teeth. When a tooth is done, *Y* is slackened, *F* drawn back, and the wheel turned to the next tooth, and the operation is again repeated until the gear is finished. We find that a boy can complete a gear of 50 teeth, rounded at one edge, in exactly 45 minutes, including setting-up time, which shows a saving of over 300 per cent. compared with hand work. HUMBER.

England.

Babbitting Boxes—Boring Holes—A Lathe Jack—Threading and Boring Tool

While employed in a jobbing shop in the oilfields I was sent out to fix the valve on a drilling engine and of course had but few tools with me.

Just as I had finished this job, up came another man who wanted an engine shaft babbitted. I told him I had neither tools nor material and as we were eight miles from a railroad and twelve miles from a town, it would take the best part of a day to get there and back. Then he informed me he had babbitt and a ladle, and if I could get along at that it would save him a day's shut-down.

We started for the well and on the way, passing a driller's shanty, procured a few yards of thread, which I used to line up the engine.

For a level I took my 12-inch scale and built a wall of stiff clay about ¾ inch high around the edge. It being winter, I always carried a small bottle of whisky with me. This came in handy, as the engine was covered merely by a roof, and water would freeze; so I poured out about ½ inch of whisky into the improvised level.

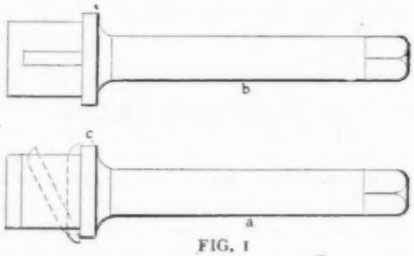


FIG. 1

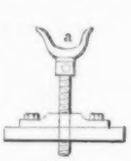


FIG. 2

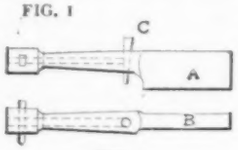


FIG. 3

SOME HANDY TOOLS

First, laying the level on the guides, I measured at each end with a 3-inch scale (which I always carried in my vest pocket); then, transferring the level to the shaft, I brought it to the same level and proceeded to babbitt. In babbitting on frosty metal, it is best to pour the metal slowly directly on the shaft and keep moving it along the full length of the bearing; otherwise you are liable to have an explosion.

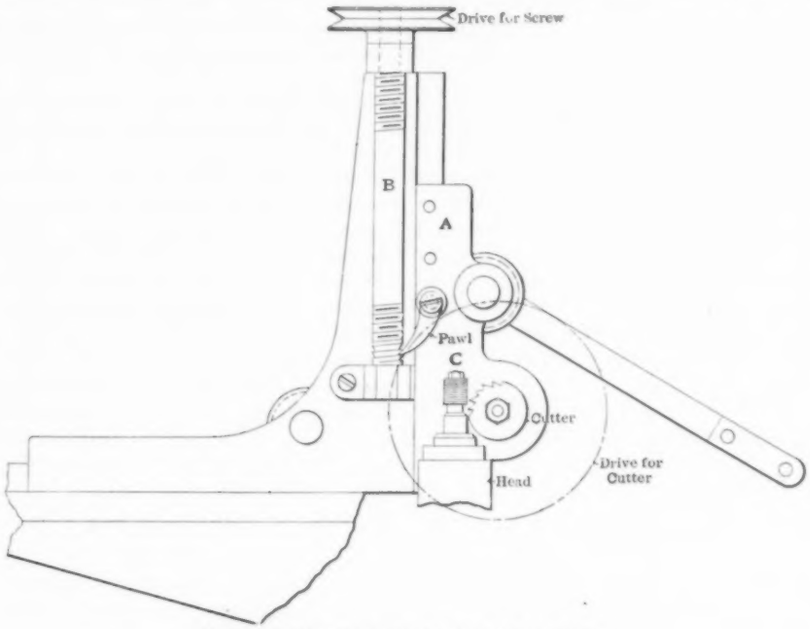
On these engines they use 150 feet of 12-inch three-ply belt. Many, who are not acquainted with the abuse they get when they find an old one half an inch out of line, are of the opinion the engine was never properly lined up. When I hung the connecting rod on this engine the other end was ⅞ inch out of line with the crosshead. Then I had the pleasure of driving four spikes in a block of wood and filing up the brasses with a 12-inch half-round bastard file, the only one I had. The engine acted very nicely, and was still running on the same metal six months later when I was called to go over the valve.

TOOL FOR BORING ENLARGED HOLE

We make an article that is bored 3¼ inches at the mouth, tapered back 4½ inches to 4¾ diameter, then bored straight for 16 inches. We first run a 2¾-inch drill and then a 3¾ reaming drill through. Then we use Fig. 1 to bore the enlarged part of the hole. *a* is a side view, *b* a top view; *c* is the cutter (note the curved cutting edges which make it center itself); *d* is

the slot for the cutter which is longer than the width of the cutter. To get the tool in the hole you twist the cutter to opposite corners of the slot, as shown by the dotted lines. Then hold the bar around to one side, and if the dimensions are correct it will enter nicely. Of course, the end that holds the cutter must be nearly the size of the hole.

I have seen many jobs on which this tool could be used, and offer it in hopes it may help someone.



CONTROLLING THE FEED OF A HAND MILLER

Lathe Jack

There are few shops that have a lathe jack, yet it is one of the handiest accessories to the lathe, not only to handle work that is too light for the crane, but to turn a job around, or to straighten a shaft, or like work. Fig. 2 is an end view; *a a* is the swivel top for round work. Other styles for square or flat work can be made.

Handy Boring and Threading Tool

Fig. 3 is a tool that some of the boys in the oilfield designed, and is not only handy but cheap to make. *A* is a side view, showing the locking key in position. *B* is a top view, showing more distinctly the round shank which we make 8 inches long, 1¼ inches at the neck, and 1¾ inches at the keyhole. It may or may not be turned a little larger where the tool goes through.

Drill a ⅜-inch hole through center to the keyhole, which is also ⅜ inch. Take a piece of cold-rolled steel *c* long enough to project through both sides about 3/16 inch; file it tapering on one side, then cut another piece, to go between the tool and the key, and you have a locking device that beats a set-screw twenty ways.

For tools some use ⅜ square for both threading and boring, while others use ¼ x ⅜ and thread only with it. A Greaser.

Controlling the Feed on a Hand Miller

In milling the teeth of small gears and pinions we use a small hand machine and with the blanks stacked on an arbor we had the greatest difficulty in getting even teeth, one tooth being thin and another thick, according to the speed at which the operator fed the cut. To make the feed automatic was a waste of time in this case, and we decided to feed by hand as of old; but we adopted the scheme shown by the accompanying sketch, whereby the operator can feed just so fast and no faster. All he is required to do is to keep a pressure on the handle. This scheme we added to our present machine, and although it may be "old as the hills" it is new to us, and it may be new to others.

It is hoped the sketch is good enough to show the scheme without much explanation. The slide *A* on feeding forward has to travel at the same speed as the screw *B*, and on returning, the pawl *C* rides over the top of the thread, dropping into mesh whenever the slide is reversed.

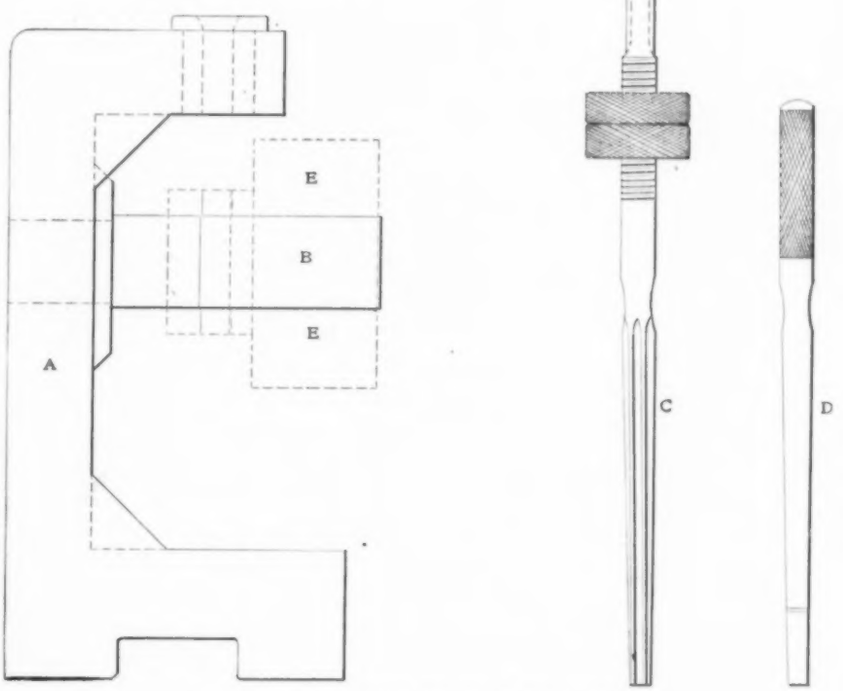
Artebe.

Drilling and Reaming Jig for Taper Holes

The accompanying sketch shows a jig, taper reamer, and test tool for drilling and reaming taper holes in gear collars or sleeves.

A is the main body of the jig, with the bushing in place. This bushing can be replaced by a drill bushing, for drilling the holes before reaming with the taper reamer. To facilitate rapid work in reaming, the work should be drilled through the upper half by a slightly larger drill than is used on the lower half, as this gives the reamer less stock to remove.

B is a piece of steel made to fit the holes of the pieces that are to be drilled and reamed, and it is made to press into the body of jig *A*. *C* is the taper reamer made to fit a Beaman & Smith drill socket, and has two nurled and threaded collars on the threaded shank. These collars are to locate the correct depth of hole to be



DRILLING AND REAMING JIG FOR TAPER HOLES

reamed. When the correct depth of hole is obtained the collars are turned on the shank to come in contact with the bushing in jig *A*, and are made fast by screwing them tight together. Two slots are milled in the outside of these collars to use with a spanner wrench.

D is the test tool made the same taper as the reamer, and having two witness marks near the small end, to serve as a "go" and a "not go" for the depth that the reamer is to cut. The lower mark is to just pass the edge of the hole, and the upper mark is to not pass the edge. When reaming the holes in the shaft on which the work is to go, this test tool can be used, the marks to coincide with the edge of the shaft.

E E shows a gear in place ready to drill and ream. C. J. S.

Tool for Boring Universal-joint Sockets

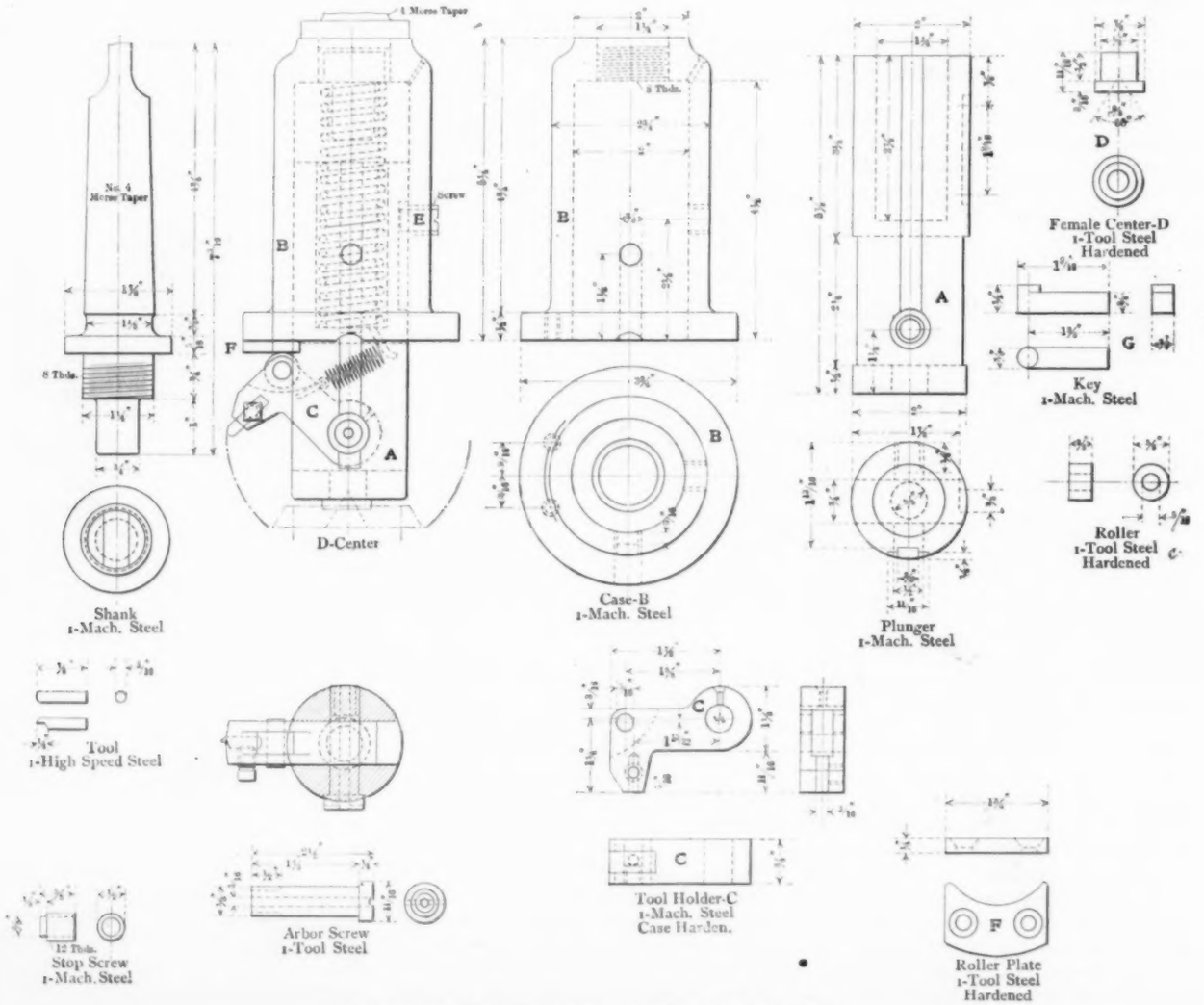
The radius tool illustrated herewith is used in boring universal-joint sockets used in automobile transmission frames and can do good work either in a drill press or in a screw machine large enough to carry it.

For the convenience of those who may wish to make a similar tool, details and dimensions are given. The plunger *A* carries the tool holder *C* with its tool point of 3/16 round, high-speed steel, and also the hardened female center *D* in its lower end. This is necessary so that the plunger *A* will not advance, but will allow the case *B* to slide over it and force down the tool holder *C* with the hardened plate *F*. Case *B* is driven by the Morse center shown, and drives *A* through the medium of the key or feather *G*, which at the same time allows the case *B* to slide on it and force down the tool held in *C*. This bores the socket to the radius of the distance between the tool point and the center of the screw on which it, the tool holder, swings. The hardened roller and plate allow an even, easy feed, with no tendency to stick. R. H. MITCHELL.

Internal Grinding—Wet or Dry?

By all means dry! As for a number of years I had to keep a number of grinding machines and about fifty internal grinding fixtures going on a product which required accurately ground holes, I think I can give some reason in support of the above statement. My practice was to clamp the water pipe with a pet cock in the end to the top of the internal grinding fixture, rough out the holes dry, then turn the water on and cool them, finishing up dry and using water only to reduce the temperature and keep it normal.

If the conditions were the same in internal as external grinding, water would be a very good thing; but they are as different as it is possible to make them. In external grinding you have a large wheel mounted on an efficient spindle running in rigid bearings, a powerful drive, the point of contact of the wheel with the work relatively small, and the ground particles instantly washed away. In internal grinding you have a small wheel mounted on an extremely light and inefficient spindle and bearing, very poor driving power and a very large point of contact of the wheel with the work. A 1¼-inch wheel in a 2-inch hole takes a much greater pressure to make it cut than a 12-inch



DETAILS OF TOOL FOR BORING UNIVERSAL-JOINT SOCKETS

wheel of the same width of face against a 2-inch shaft.

Although water is essential to good grinding, it certainly has a glazing tendency, and the very obect it accomplishes in external work—that of keeping down the heat—tends to make the particles of steel harder to cut off. This is of no consequence at all on external work, as the mountings of the wheel and the work and the power available to drive them give a good margin to overcome this trifling drawback. When this extremely slight extra pressure is brought on the internal wheel spindle and bearings it is another matter, both as regards the amount of metal removed by a pass of the wheel through the work and the greatly increased wear on spindle bearings and belt. All of our grinders were run on piece work or a premium basis, and it was tried repeatedly wet and dry under all conditions, and I am sure that with the fixtures now in use more efficient grinding can be done dry.

The fact remains, however, that all the internal-grinding fixtures yet built are only individually fit to do an occasional job with and then take a good, long rest. When you run a number of machines on internal grinding day and night, month after month, it means a department to make and maintain internal grinding fixtures. We used every kind that could be bought in stock, and designed and built, or had built, a score of other kinds using plain bearings, ball bearings, and roller bearings, even one with a system of oil pressure around the spindle. I think that the roar some of these freaks made is echoing yet. My conclusion is that we have not yet any reason to find fault with the fixtures furnished by the regular manufacturers, and that the best fixture is the one most easily repaired and replaced. That of course cuts out anything but the plain bearing and spindle. Ball bearings do very well for a time on the larger sizes using a 3- or 4-inch wheel, where the speed is more moderate; but on the small sizes, where the velocity of the supposedly rolling balls is nearly as high as that of a bullet from a modern rifle, they are a failure, and I do not mean some particular type of ball bearing, but all of them. Our proposition was hard enough to make it worth while to try everything which gave the slightest hope of keeping our internal-grinding wheels constantly throwing out sparks.

SPARKS.

A Recessing Tool for the Turret Lathe

To cut a recess *a* in the casting shown in Fig. 1, the tool in Fig. 2 was designed to fit in the turret of a hand machine, the tool posts being full. This recessing tool when made up produced good results.

A is a steel shank over which are fitted the ring *B* and the cap *C*, which is hardened and ground and tee-slotted to receive the slide *D*, which carries the cutter *E*.

A pin in the slide is engaged in the slot in ring *B*, the movement of the ring forward or backward giving the slide a horizontal motion. The spring held between two posts *F*, one in the cap and one in the slide, forces the slide back when the lever is released, bringing the cutter under cover, so that it clears when the tool is withdrawn. The cutter is readily removed for grinding by removing screws *G* and *H*. Notches in the cutter and slide keep the former from slipping when set in proper cutting position. The cap *C* acts as a pilot, and the distance from its face to the cutter serves as a gage.

With the stops on the ring and shank the whole arrangement is quite error-proof.

GERALD.

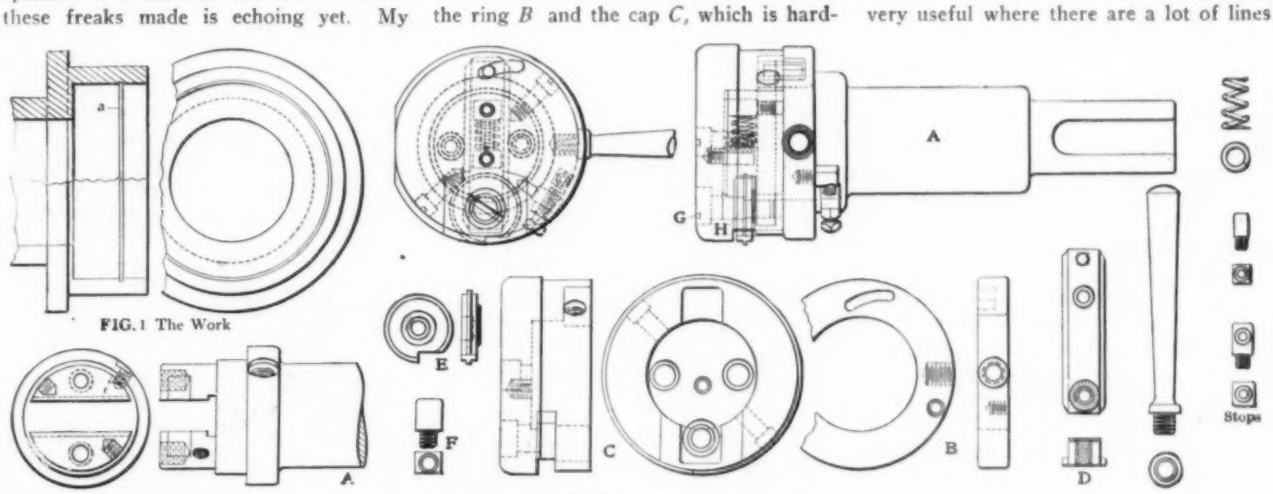
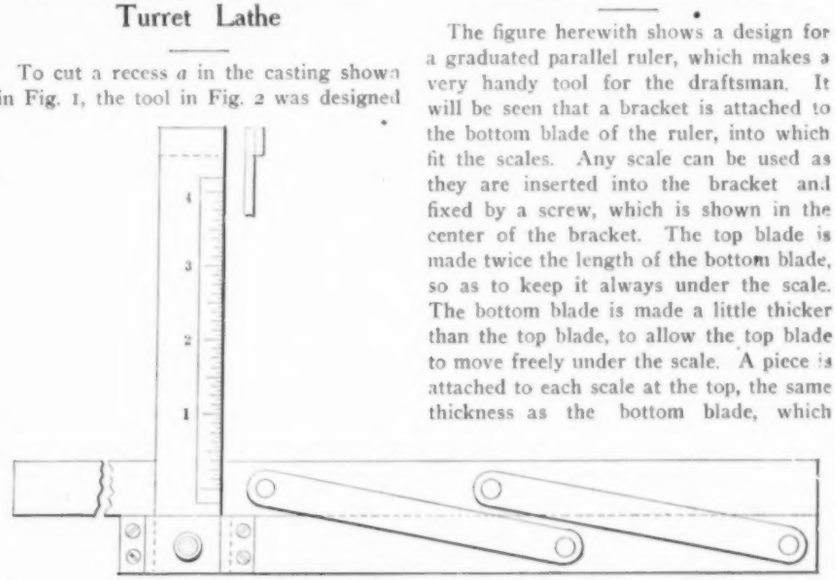


FIG. 1 The Work

RECESSING TOOL FOR THE TURRET LATHE

Graduated Parallel Ruler

The figure herewith shows a design for a graduated parallel ruler, which makes a very handy tool for the draftsman. It will be seen that a bracket is attached to the bottom blade of the ruler, into which fit the scales. Any scale can be used as they are inserted into the bracket and fixed by a screw, which is shown in the center of the bracket. The top blade is made twice the length of the bottom blade, so as to keep it always under the scale. The bottom blade is made a little thicker than the top blade, to allow the top blade to move freely under the scale. A piece is attached to each scale at the top, the same thickness as the bottom blade, which forms a bridge over the top blade when in use. It can be used by placing it against the T-square, or at any angle after the first line has been drawn. It will be found very useful where there are a lot of lines to be drawn parallel to each other, as they will not require to be picked off with the pencil and scale before being drawn.



GRADUATED PARALLEL RULER

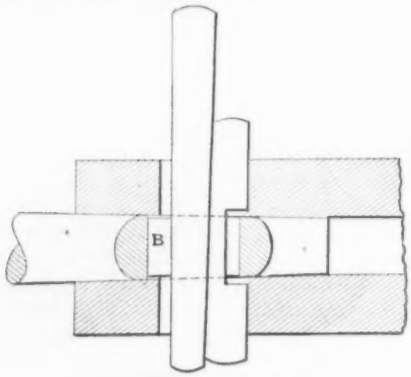
To use the ruler: if two or any number of lines are to be drawn parallel to each other, the ruler is placed against either the T-square or any line that has already been drawn. The bottom blade is then pressed on to the board, and the top blade opened out to any dimension required, and pressed down, while the next line is drawn. Any

number of lines up to 4 inches can be drawn without moving the bottom blade.

England. A. J. W.

Pouring Babbitt—Getting a Rod out of a Crosshead—Blowing out a Piston

The boss had put a couple of boys to babbitt some boxes. They had a great deal of trouble to get the babbitt to run.



GETTING THE ROD OUT

They tried the babbitt at all temperatures, from just melted, to red hot. They heated the mandrel and boxes. They poured fast and poured slow, but failed to get a good box. Then the boss tried one and when he opened the box it proved to be a fine job; the babbitt had run perfectly. After showing it to the boys, who were very much surprised, he said; "It is all in knowing the trick. The trick in this case is getting another kind of babbitt." It would be a good trick for the buyer to buy another kind of babbitt.

Taking Out a Crosshead

We had a rod to take out of a cross head. There was no chance to drive a wedge between the pin and the end of the rod, the usual way; and to drive the crosshead off would batter up the boss until it would look like sin. After some study I hit upon the plan shown in the illustration which almost explains itself. The block *B* is dropped in place and the key, bearing on this, drives out the rod.

The piston in the air hammer stuck. In this hammer there is no way to get behind the piston to drive it out. The "all-around man" tried jolting it on the floor, then on a chunk of lead. He pumped the air up to 200 pounds and used it in connection with the jolting. He could move the piston, but come out it would not. It appeared that he was up against it proper. They needed the hammer very much and to send it to the factory would consume several days.

Finally he hit on a plan that fetched it and that may interest other "all-arounds." He remembered his boyhood days and concluded to shoot it out. He drove the piston nearly back; took out the throttle and main valves, and filled the chambers with asbestos; took out the auxiliary valve which opens just back of the piston; then he filled up the space with gunpowder. He bought a package of fire crackers and pulled the fuse out of one, and inserted it in the small exhaust port; took the hammer out behind the shop, laid it on a couple of blocks, and pointed it at a block of wood; touched off the fuse and ran. It fetched the piston and did not damage the hammer either.

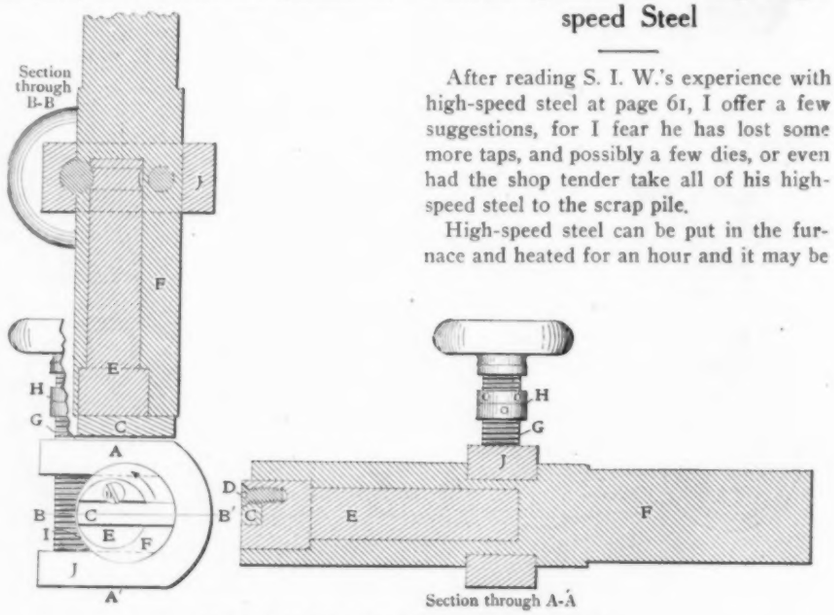
Sometimes it is very difficult to inset the nipple in air-brake hose. Often these nipples are a piece of common pipe. Take the job to a fire and heat the nipple to a blue heat, and it can be inserted very easily. Have a bucket of water handy to immerse the end in as quickly as possible, so as not to spoil the hose. I always do this job near the slack tub.

W. A. Bright.

A Tool that Failed to Work

There are supposedly very few tools and fixtures described on these pages but that will perform the functions for which they are designed. I have often thought that if some of the failures were described more frequently, some great and good lessons could be learned therefrom. I am not actuated by any feeling of pride in describing this failure, but hope it may help some pencil-pusher when he may have a similar tool to make.

We had a job of undercutting to do on a piece we manufacture, and I had already designed a tool that did this operation until the cutter blade was worn out, after which it had to be renewed by making a whole new blade. This was a costly job to do, hence I bethought me of this "failure," where the cutter could be removed and replaced at small cost and with no outlay of time.



DETAILS OF THE TOOL THAT FAILED TO WORK

In the first place, the tool was designed to be operated while in motion; that is, the throwing out of the tool into the work and the withdrawing of it again were done while the spindle of the machine was turning—the spindle revolved very slowly. A reference to the drawing shows a shank *F* made of machine steel. This was made to fit the "ball chuck." The member *E* is of tool steel, and carries on its lower end the tool *C*, shown plainly in the section and plan. The flat-head screw *D* retains the same on the member *E*.

Now a study of the plan shows the tool at rest or out of working position, and it was supposed to move in the direction of the arrow, by the turning of the worm screw *G*, around toward the shoulder *I*, until the stop nuts *H* came in contact with the retaining member *J*.

Perhaps you have already seen that the tool would not budge, not in a thousand years, if it depended on this screw *G* to turn it, because the screw simply traveled in or out without any power whatever to move *E*. Simple, isn't it?

Some tools look like non-producers on paper, and they fool us and exceed our fondest hopes. Others look good to us until the finishing touches are put on—then we swallow hard, take another hitch and try again.

By substituting a stationary worm in the place of the member *G*, this tool was made to perform its functions; but it was not so good a tool as the first design.

Carroll Ashley.

Annealing and Hardening High-speed Steel

After reading S. I. W.'s experience with high-speed steel at page 61, I offer a few suggestions, for I fear he has lost some more taps, and possibly a few dies, or even had the shop tender take all of his high-speed steel to the scrap pile.

High-speed steel can be put in the furnace and heated for an hour and it may be soft or it may not; for it must be handled properly, and if you have not had much experience, order a bar for that purpose; it will be the most valuable of any bar of steel you ever had. Why take a piece of steel that is intended for a tool, and experiment with that? Be sure you have learned how to anneal before you try to

anneal a piece intended for a tool. The manufacturer of today is looking for the most modern machinery, the best tool-maker and machinist, but in his hardening department you find a blacksmith forge with a blacksmith or tool dresser to do the hardening. There is not a man in the employ of a tool shop who can make or save the money that a tool-hardener can.

Some men think, because they can harden a drill, a lathe tool, a tap, and even a few small dies, that they are ready for any kind of a tool. A tool-hardener must know what is in the inside of his die or tool, and must know what is required of a tool.

How to Anneal

High-speed steel is annealed by heating, not by cooling. It does not require more than 12 hours for a piece of 2½x10 inches to cool. There are a great many ways that this steel can be annealed, but instead of a crucible, get a cast-iron box and some cast-iron shavings from your planer or lathe and pack your work in this. If you have not got the shavings or box, take a gas pipe and pack the work in charcoal; or use ashes, dirt, clay—anything that will not burn on the work to be annealed. Heat it for 7 hours, running the heat as high as 800 degrees Centigrade; hold it at this point at least 5 hours, then raise the heat to 900 degrees Centigrade (cherry red); shut off your fire, and close your furnace door; take out the steel after 12 hours.

Hardening High-speed Steel

Now, as to the hardening of high-speed steel. Do not use borax or cyanide or anything else. High-speed steel does not get hard by cooling the steel; it gets hard because it is heated to the proper heat. You can use a pound of coal oil and 10 pounds of borax and 5 pounds of cyanide on any tool you please; but if you get the proper heat and then throw the tool at the apprentice boy, or throw it in fish oil (as you ought to do for fear of hurting the boy or the tool), you will find that all your compounds for cooling high-speed steel are a mere expense and an injury to the tools.

The tool receiving the proper heat will do what is required of steel of this kind, regardless of the cooling. It is possible and practical to make any kind of a tool, used in the manufacturing line, of high-speed steel so that it can be hardened and strengthened with ease, the same as carbon steel. It is also practical to make finishing tools of high-speed steel, as well as to make the cutting edge of some tools high-speed steel and the other part common steel, welded to the high speed. These tools are difficult to harden, but it can be done with care and with paying results.

I have been doing nothing but hardening tools for years. I love my work, and do not like to see good steel and hard work go to the scrap pile, and have it said that it was the fault of the steel. My experience has taught me that there is not one bar out of 5000 bars of steel that the steel-maker should replace.

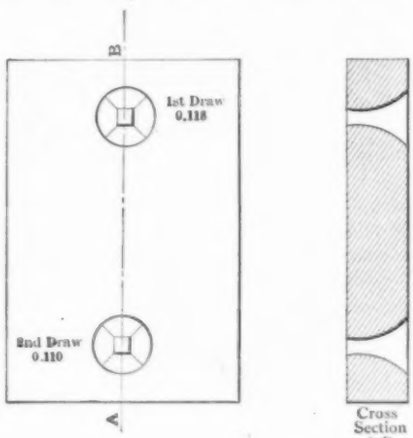
C. U. Scott.

Drawing Square Rod

In a prominent factory, bright machine steel 0.11 inch square was wanting in the screw department to make small set screws; also to try a new screw machine for the manufacturing of parts, about 100 feet being required for a trial. This being an odd size the manufacturers of such stock could not make it within three months' time, owing to orders ahead.

Our round machine-steel list was complete, at most every size one could wish for.

Acting in the capacity of assistant or working foreman of the tool department, I



DRAWING SQUARE ROD

had orders to produce 100 feet 0.11 square. A number of suggestions were offered, such as slitting sheet metal of the right thickness on the milling machine, swedging die, and rolling. After several trials of the different methods advanced it looked like a long row to hoe. We had plenty of different size round stock. Why not make a drawing die and draw it on the planer?

A flat piece of Firth-Sterling die steel ½x2 inches by 3 feet, was selected, and a hole drilled at either end, the diameter smaller than 0.11. A ½-inch drill was run in about half way to save filing. Two short broaches were made 1½ inches long, one 0.108 square, the other 0.116, with teeth filed for cutting, and tempered. This allowed 0.002 to finish after the broach had been forced through the die.

The mouth of the die should be rounded, as shown, so the stock will draw easily. Harden glass hard, removing only the strain; polish with pine stick, oil, and powdered emery; thus you will have a breaking down die at one end, and a finisher at the other.

Clamp a milling vise on the extreme rear end of the planer bed with the die in the vise, the large or roughing end of the die up. The end of the stock is filed so it will pass through the die and fasten to the planer tool. Start up the planer, letting the stock pass through the die. When it is all broken down, turn the other end of the die up and finish. If the die is glass hard, the stock will not vary 0.0002 in 100 feet.

I started with round stock 0.14 diameter; it left a small round corner, just enough to save burring. The first time it was run through, a 6-foot piece stretched 18 inches; the second draw stretched it six inches more. So taking this as a basis a piece 4½ feet long, when trimmed, would give about 6-foot lengths.

About five hours were required to make the broaches, filing and hardening the die.

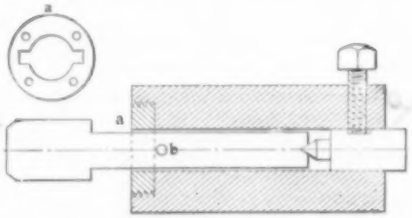
The same length of time was consumed in drawing out the stock, with the aid of an apprentice boy to clamp and oil the stock passing through the die. Barnie.

Floating Reamer for Turret Lathe

For very accurate work the floating reamer has come to be the standard. Here is one I have used very successfully on a Jones & Lamson turret.

The reamer is flat, turned between centers, and held loosely in a holder, as shown, against a center at the back end. It has a pin through it at *b*, which fits into a recess in the sides of the holder to prevent turning.

The nut *a* has slotted sides which pass over the point of the reamer and hold it in place. By turning the slots at right angles to the pin it is made to hold firmly against an outward pull, as in withdrawing from the work.



FLOATING REAMER FOR TURRET WORK

This is the joint design of our foreman, H. H. Segner, and myself.

W. E. Fickes.

The report of the president and treasurer of the Massachusetts Institute of Technology contains also the reports of the various departments of the institute, among which it is interesting to notice a 30-page report on the leading European schools of naval architecture. Recommendation is made for the establishment at the institute of a towing tank or experimental-model basin. The number of students during the year was 1397, a decrease of 69 from the previous year. The instructing staff numbered 191, excluding research associates, assistants, etc.

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The Condition of the Patent Office

In connection with the recent report of the commissioner of patents, showing the excellent condition of the work in the United States Patent Office, all patent practitioners are apparently not entirely in accord with the statements of Park Benjamin, published on page 753, Vol. 29, Part 2. Francis H. Richards, the well known mechanical engineer and patent expert of New York City, tells us that he does not agree with Mr. Benjamin that the condition of the work in the office warrants criticism. It is probably true that at times the actions of the office are not such as an attorney would like. This may be due to the mode of prosecution by the attorney himself, the way he prepares his case, or to the fact that he may not view the prior art cited as the office does. It is probably true that at times an attorney receives what might be considered an unsatisfactory action, but this is not, according to Mr. Richards, the rule, but the exception.

In view of several recently published criticisms of the work of the office, Chester A. Weed, a patent lawyer, who has been for many years chief counsel in the office of Mr. Richards, states that he is in a position to know how the present improvement was brought about, and that the entire credit for this improvement is due to officials of the patent office, and he believes that the commissioner of patents should have the credit to which he is justly entitled for this excellent condition of the work, which in Mr. Weed's experience of some twenty years has never before existed in the office, considering the average daily number of patent applications filed.

The first criticism referred to appeared in one of the New York papers under date of September 1, 1906. For some months prior to that date, however, the present commissioner of patents had been endeavoring to work out some method for facilitating the work of the office and bringing it up to date; and long before September 21 the commissioner was carefully considering the advisability of appointing a committee to formulate a plan of bringing, and if possible, keeping, the work of the office up to date, and on September 19 he appointed a committee composed of a number of the principal examiners of the office to consider and suggest a plan to better the condition of the work of the office. This committee formulated a plan and it was immediately put into operation by the commissioner. As the result of the appointment of this committee; of the adoption of the plan suggested by it; of the coöperation of the examining corps with the committee, and with the commissioner; and of the manner in which the commissioner, the helmsman as it were, has kept in touch not merely with the work of the divisions of the office, but with the work of each examiner, the work of the office has been brought up in such manner that instead of waiting, after an application for a patent was filed, some five, six, seven, or even eleven months for official action thereon, as was the case a year ago, such official action is made in nearly all of the divisions of the office within one to three weeks, and at the outside within four weeks; and the actions most certainly compare favorably with those of a year ago and are with but minor exceptions satisfactory. For instance, a year ago, a case filed in one division on May 4, 1905, received action nearly nine months later, or on January 30, 1906. Recently a case filed in this same division on December 31, 1906, received action on January 8, 1907, about four weeks later, instead of nearly nine months.

The present commissioner has personally worked out a scheme whereby he is not merely in touch with the condition of the work in each division of the examining corps, but is acquainted with the standing of each examiner's desk in the office, as to the number of cases on his desk awaiting action, the number acted upon during the current week, and the number remaining unacted upon during such week; and when it is remembered that there are 39 divisions, with approximately six examining desks in each division, or a total of 234, each having weekly from a half dozen to many dozens of cases on it, some divisions having many hundreds of cases awaiting action, some appreciation can be had of the vast amount of work involved in perfecting such a scheme, and in adopting and carrying out any plan which would bring and keep the office up to date in its work.

The weekly number of applications being filed is, however, on the increase and not on the decrease, and Congress can very materially assist in keeping up this excellent condition of the work by giving its careful consideration to and passing the bills now before it, having the approval of the Patent Law Association. The number of the examining corps in the patent office should be yearly increased, and the salaries of the examining corps, as well as of those officials who have a quasi-judicial position, should be materially increased, to the end that experienced men may be retained in these most important positions. More pay from the outside is frequently severing the connection of these men with the office. This alone is believed to be one of the material factors in delaying the work of the office and causing it at times to fall behind.

It is to the interest of inventors that these measures should be passed. As was stated in a report of a special committee of the Patent Law Association, of Washington, under date of November 1, 1906:

"The inventors of the United States are not asking any favors. In the fiscal year

ending June 30, 1906, they have put into the United States Treasury a profit or surplus of receipts over expenditures of the patent office amounting to $275,148, and since 1837 there has been covered into the United States Treasury over six million dollars derived from the same source."

Tariff Relations with Germany

The following very recent official statement upon the question of our tariff relations with Germany may not be without interest at this time. It may be remembered that a resolution was offered in the House a short time ago calling upon the President for information as to what arrangements have been entered into between the United States and Germany affecting the tariff and what negotiations have taken place between the two countries on the subject. The resolution has been reported back to the House with the recommendation that it be not passed and this step is taken because of a communication received from Secretary Root, suggesting that he does not think it would be wise for the House to call for this information at this time. He states further that no agreements have been made between this country and Germany since the *modus vivendi* established last year, and communicated at that time to Congress. As matters now stand the maximum tariff will take effect as against imports from this country on June 30 next, unless something is done to prevent it, but he gives it as his opinion that it would not be compatible with the public interests at present to make public any of the papers involved in this negotiation.

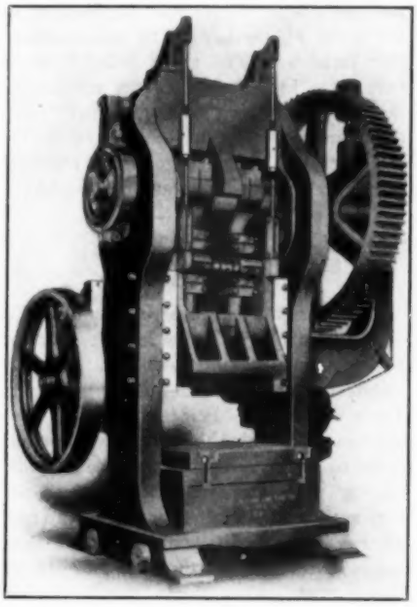
Eight cylinders on two wheels appears now to be the motorcycle record, this being a forty-horse-power machine taken to the Florida speed carnival. The cylinders are arranged in pairs at angles of 45 degrees each side of a central vertical plane, the transmission being through a longitudinal shaft and bevel gears. The length of the wheel-base and of the handle-bars is pretty big. It was soon disabled, in fact before it did anything worth mentioning. A two-cylinder 14-horse-power machine cut the motorcycle record for the mile to 44 2/5 seconds, flying start, straightaway, not in competition.

The Eiffel tower seems to be quite a standing problem to the French. Last year we were informed of the extension of its term of life for some years; the latest bulletin states that it has been decided to make it a permanent part of the army wireless telegraph system. From the tower, at a hight of 900 feet, communication has been held by radiotelegraphy with Berlin and with London.

NEW TOOLS AND MACHINE SHOP APPLIANCES

Large Power Press

A large double-pitman double back-geared motor-driven press of a new size, designed for the hot pressing and forming of couplings for oil pipes and similar work, as well as for cold pressing, is



LARGE POWER PRESS

shown by the illustration herewith. The distance between uprights is 61 inches, and the bed is 48 inches from front to back. The stroke or slide motion is 8 inches and the adjustment of the slide 4 inches. The frame is a single casting, weighing 29,000 pounds. The clutch mechanism is of the three-engagement, automatic-block type, with gravity releasing mechanism. The motor, which is 20 horse-power, can be partly seen in the picture to the rear on the right side of the machine. The ratio of the gearing is 30:1; the large gear is 85 inches diameter by 12 inches face; from its top to the floor the hight is 11 feet 8 inches. The machine has a total weight of 73,500 pounds; it is designated size No. 96½ by the builders, the Toledo Machine and Tool Company, Toledo, Ohio.

A Grinding and Polishing Machine

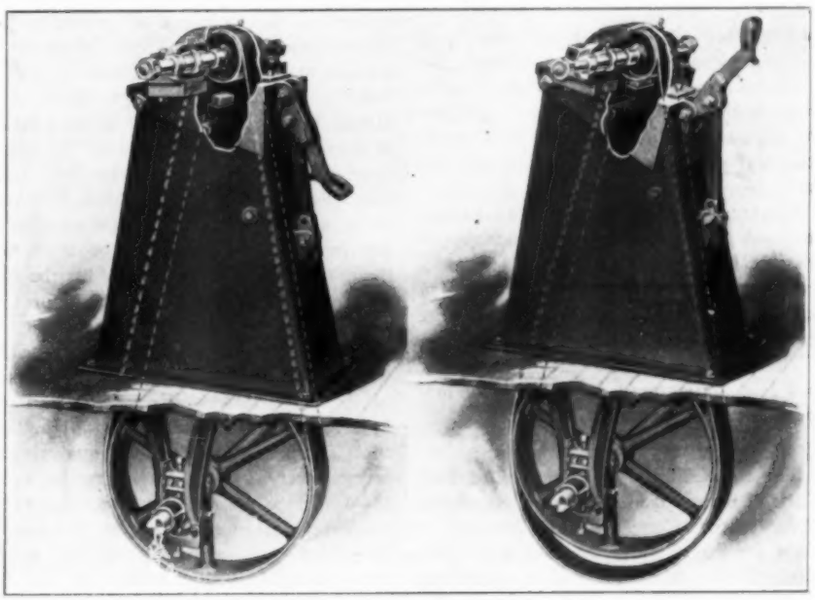
The illustrations show a grinding and polishing machine in which there are no overhead belts or shafts to interfere with the handling of the work.

As is readily seen, there is but one belt used, which is entirely inclosed and out of the way of dust and dirt. The belt can be thrown off or on instantly.

By lifting the toggle lever, shown in Fig. 1, the hinged top, which carries the bearings, hood, flanged sides and apron, is dropped so that the belt is clear of the driving pulley on the shaft beneath the floor, as shown in Fig. 2.

When work such as sadirons is handled on a lever under the wheel, exerting great upward pressure, an up-stop is provided to lock the top.

These grinding and polishing machines are made by the New Britain Machine Company, New Britain, Conn.



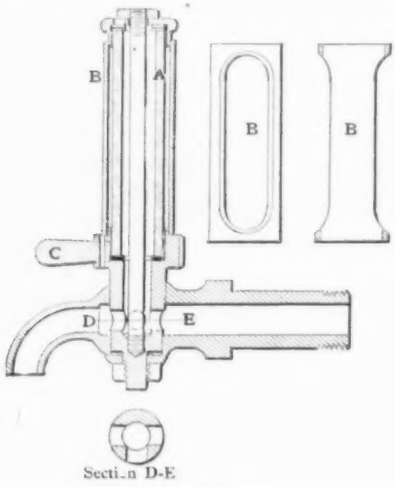
FIGS. 1 AND 2. THE GRINDER IN AND OUT OF COMMISSION

An Oil Gage

The illustration shows an oil gage for use on dynamos and other machinery having self-oiling journal boxes.

The gage glass *A* is protected by a metallic shield *B*, free to turn, having two oblong slots, through which the hight of oil can be seen. The glass is easily cleaned by placing a piece of waste against the glass tube and revolving it with the shield. The fact that the shield can be revolved makes it possible to observe the hight of oil in the gage from any point, by simply turning the shield until the glass can be seen through one of the slots.

Turning the ground key located in the bibb-nose body by means of the small handle *C* attached directly below the shield makes it possible to drain the shield independently of the journal-box oil receptacle; or, by turning the key in the opposite direction, both the gage and the oil receptacle can be drained. By placing the handle parallel with the bibb-



AN OIL GAGE

nose drain, the gage can be made to register the amount of oil in the journal-box oil receptacle, and the drain is closed. It will therefore be seen, that, should the gage glass be broken, the oil can be drained therefrom, without necessitating the drainage of the oil from the journal-box oil receptacle, and the glass can immediately be replaced.

A wrench applied to the small hexagonal nut at the top of the gage makes it possible to remove the gage glass, as it and the shield are held in place by a rod running through the center of the gage and screwed into the key.

The gage is known as the "Triplex," and is manufactured by the Lunkenheimer Company, Cincinnati, Ohio.

The Keuffel & Esser Company, of New York, has acquired from the Spaulding Print Paper Company, of Boston, all right for the manufacture and sale of the Federal blue-printing machine which was illustrated in our columns at page 36, Vol. 28, Part 1.

Users of tracing cloth, many of whom are among our readers, will be interested to know that an American company, known as the American Tracing Cloth Company, with offices at No. 11 Broadway, and with a manufacturing plant at Paterson, N. J., has prepared for manufacturing a very high-grade tracing cloth. It has been necessary heretofore to import such cloth from Europe.

The Schellenbach & Darling Tool Company, Cincinnati, Ohio has recently made made some unusually large reamers. The bodies of these reamers are made from steel forgings. There are six reamers in all, from 7¾ inches to 12 inches diameter inclusive. The arbor holes in them vary from four inches for the smallest to five inches for the largest. Apart from their unusual size these reamers are in other respects standard goods. The weight of the six reamers is about 1000 pounds.

New Publications

"Principes de la Construction des Machines-Outils." By Jules Merlot. 646 pp., 7⅜x10⅞ in.; 987 illustrations. Librairie Polytechnique, Ch. Béranger, Editeur; Paris and Liège. Price, 40 francs.

Though machine design, in the usual sense of instructions and formulas for designing parts for strength and wear, do not, with a few exceptions, form any part of this book, it will probably be of more use to students of machine-tool design than to any other single class. Certain elements of machines are in the beginning discussed without very much elaboration, and then the different kinds of machines are taken up separately and their general principles discussed and illustrated by one or more specimens of each type. Catalog cuts predominate, and we presume as a set-off to this fact the names of the makers of the tools are not given, which is sometimes to be regretted. In the early portion of the book are treated such subjects as fastenings, bearings, slides, and organs for the transmission of movement, in which discussion is given of the efficiency of screw and nut mechanism; friction wheels, and gears, in which, however, there is none of the usual matter regarding forms and proportions of teeth, although we find some formulas for the size of arms. The subject of belt shippers is given a fairly complete treatment; in the chapter on mechanism for varying speeds, we find the means of figuring the lengths of open and crossed belts for cone pulleys, by trigonometry. The subject of cutting tools is introduced by an analysis by trigonometry of the forces acting upon them; this is followed by the subjects of processes of making tools, hardening, tempering and grinding, special steels, form of tools, cutting speeds, etc. In the chapter on generalities concerning the construction of machine tools, we find arguments in favor of machines as simple as possible, not requiring high-priced and extra intelligent operatives to handle them; and the author deprecates the use of machines, as he says, "so called adapted to everything, but ordinarily not good for much." The subject of power absorbed by machine tools is developed on the basis of the formulas arrived at in the part treating of cutting tools. Some very sensible remarks are given about the proportioning of parts of machine tools; for instance, after referring to the fact that the sizes of certain parts, such as diameters of pulleys, can be determined exactly by calculation, other parts are determined approximately by the application of the formulas of the strength of materials, while the greater number of elements are determined by comparison, or by formulas derived by each constructor as the result of experience; considerations of molding, forging, or other processes of manufacture also having a strong influence upon design.

We have received a very interesting address delivered by V. Karapetoff before the New York Electrical Society on The Human Side of the Engineering Profession, and dealing with the ethics of engineering and the ideals which the engineer should keep before him. The address is published by the author at Ithaca, N.Y.

It makes a beautiful experiment to watch the alternate flashes in a mercury-arc converter at work, with the aid of a stroboscopic disk. A disk with a hole in it is interposed between the converter and the observer, and is driven by a motor. The speed of the motor must be controlled so that the disk is almost in synchronism with the alternations of current supplied to the mercury arc. At exact synchronism the flashes at one anode will be seen apparently sustained, like an arc lamp. At a speed slightly below synchronism, the flash is seen slowly to leave one anode, run down that side, contract into the cathode, run up the other side and catch on to the other anode, the seizure of the latter being completed before the release of the former is over. The handing over of the arc from one anode to the other, which may actually occupy one two-hundredth part of a second, is thus drawn out stroboscopically to many seconds.—*Electrical World.*

The multiplication of cylinders in the internal-combustion engine continues to go on. The six-cylinder motor car was quite in evidence at the recent automobile show in New York. We referred at page 97, Vol. 29, Part 2, to a 16-cylinder engine, but this record is far surpassed by a 24-cylinder Antoinette boat engine at the Paris show; its rated horse-power is 360, and its weight 1320 lb., so that the weight per horse-power is about 3.6 pounds.

Calipers and the Art of Calipering

What It Means To Work To One Thousandth Of An Inch. The Tools To Do It and Examples Of How It Is Done.

BY FRANK A. STANLEY

In the preparation of material for this supplement we have selected from the files of the AMERICAN MACHINIST certain contributed and editorial articles dealing with various phases of the extensive subject of "calipers and calipering." Certain of these articles are reprinted in the following pages substantially in their original form; others are abstracted with sufficient fullness to cover the essential points brought out by their authors. So far as practicable this material has been classified and grouped under distinctive heads.

Evolution of the Spring Caliper—Some Interesting Particulars Regarding this Tool, as Related by a Former Foreman of a Small Tool Shop

A number of incidents and changes that have taken place in the evolution of the spring caliper may be of interest to AMERICAN MACHINIST readers.

The J. Stevens Company—afterward the J. Stevens Arms and Tool Company—

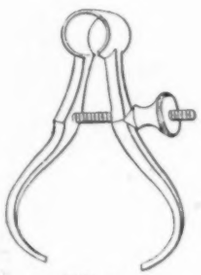


FIG. 1

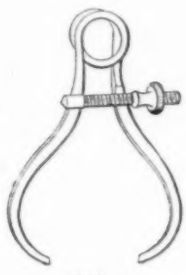


FIG. 2

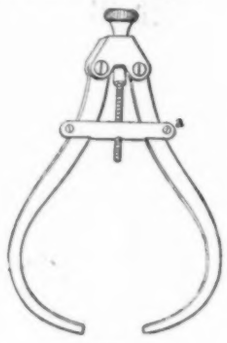


FIG. 3

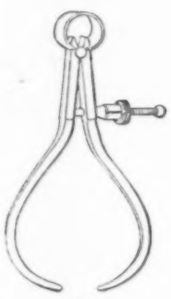


FIG. 4

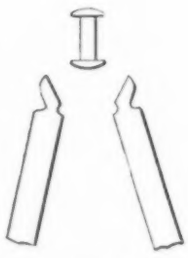


FIG. 5

FIG. 6

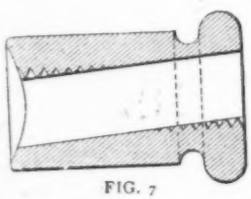


FIG. 7

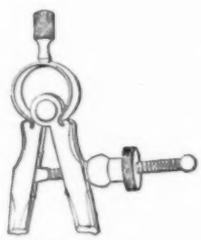


FIG. 8

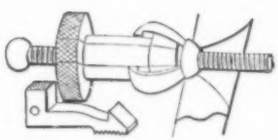


FIG. 9

THE EVOLUTION OF THE SPRING CALIPER

Among those from whose contributions to our columns selections have been made are the following: Daniel Adamson, Walter Cantelo, J. H. Dunbar, W. D. Forbes, S. W. Goodyear, Henry Hess, E. R. Markham, John Riddell, William S. Rowell, James W. See ("Chordal"), Professor Sweet, Oberlin Smith, John Slocomb, George F. Summers, P. V. Vernon, Prof. J. J. Wilmore. of Chicopee Falls, manufactured for years a spring caliper patterned after the English tools which were sold in this country as the "Stubbs" calipers.

EARLY METHODS AT THE STEVENS SHOPS

I can remember as a boy 6 years of age going into their blacksmith shop and watching Grandpa Spalding—as he was known to the village boys—forging calipers and dividers. The legs and bow were made, as will be seen by a glance at Fig. 1, in one piece. There was at this time no drop or power hammer in the shop; all drawing of stock was done with hammer and sledge, and the shapes were produced with special hand tools and forms rigged up as jumpers. The calipers, after being forged, were sent to the machine shop to have the necessary machine work done on them, after which they were returned to the blacksmith shop to be hardened and tempered. Little did I think as a lad of 6 years that 21 years after I should have charge of making this very caliper in this shop—but I am getting ahead of my story.

HELICAL COIL SPRING CALIPER

After manufacturing this caliper for many years, the company put on the market what was known as their patent helical coil spring caliper, a sketch of which is given in Fig. 2. This was made from steel wire; the spring was coiled and the legs flattened and bent to shape. It was necessary to cut a slot nearly the entire length of the screw, leaving it solid at each end; the slot was necessary, as the screw had to straddle the legs. This tool never met the expectations of the company as a revolutionizer of the caliper business.

MR. FAY'S INVENTION

About the year 1878 Charles P. Fay, working as an apprentice for the above mentioned concern, invented and had patented a caliper of the form shown in Fig. 3. He afterward sold the patent right to a Mr. Hyde, of Springfield, Mass.; it was known as the Hyde patent screw caliper. The operation of the caliper will be seen by a glance at the illustration. Two coil springs which were inserted in the cross-bar *a* kept the legs against the screws shown at each end of the bar; but as there was no provision for taking up wear in the joints or back lash in the screw, the popularity of this tool was short-lived.

DETACHABLE BOW CALIPER

Shortly after this Mr. Fay invented and had patented a detachable bow caliper, which differed from the Pond caliper made in Worcester, in that the bow was placed above the joint of the caliper and opened it by compressing the upper end of the legs, as shown in Fig. 4. As the pressure of the bow kept the legs together, all that was necessary for a fulcrum was a pin fitting in a semi-circular shaped slot in each leg. An idea of the fulcrum pin—or joint stud—is given in Fig. 5, which also shows a view of the legs and slot to re-

ceive the pin. Mr. Fay started the manufacture of this caliper in Springfield, Mass., in 1885. I went to work for him in the fall of the same year, and shortly afterward was appointed foreman of his shop.

QUICK-ADJUSTING NUT

During the summer of 1886 he placed on the market a cheaper form of his caliper and divider, known as the "Yankee;" his object in making this caliper was to meet the cheaper forms of goods sent to this country from Germany.

The quick-adjusting nut put on the Fay caliper and divider, and on the Yankee, when ordered, is shown in Fig. 6. This nut, after being made to shape and drilled and tapped in the screw machine, was placed in a jig and hollow milled on two opposite sides to receive a ring. After the hole in the small end of the nut had been elongated, it was sawed in two and filed, to allow the small end to close in order to open the opposite end that contained the thread, and to release it from the screw; a ring was soldered in opposite sides of each part of the nut, which was then put together and polished.

OTHER RAPID ADJUSTMENTS

At some time previous to the putting of the Fay quick-adjusting nut on the market, the nut shown in Fig. 7 was brought to our notice. At about this time —I cannot recall the precise date—another form of quick-adjusting nut, known as the Richardson rapid nut, was added to the list, and was used by the Stevens company in connection with their calipers, when ordered.

In 1887 I accepted a position with the J. Stevens Arms and Tool Company, in charge of their fine-tool department. They had previously brought out a detachable bow caliper, whose legs were joined together by means of a half-and-half joint, the bow being connected with the legs below the joint and operated similarly to the Pond caliper bow. Fig. 8 shows the joint and bow. Shortly after, the joint was changed and a compression bow substituted for the bow formerly used, on account of the possibility of getting a much evener tension. The form of quick-adjusting nut then used by them is shown in Fig. 9.

FURTHER CHANGES

They afterward put on the market a cheaper form of caliper, known as the Leader. They continued to manufacture the solid forged caliper up to the time I left their employ, in 1895, but on a very small scale, as the detachable bow goods gave much better satisfaction, and the tension of the bow was much evener, especially on the large sizes.

In 1887 L. S. Starrett, of Athol, Mass., bought out the Fay and Yankee caliper and divider, and with some slight improvements is manufacturing them now.

SOME GAGING AND MEASURING METHODS IN AMERICAN AND BRITISH SHOPS

Large Micrometers and Other Calipers—Their Use by Inspectors and Machinists —Gaging Big Work

The basis of all shop gaging done at the works of the Westinghouse Machine Company, in East Pittsburg, Penn., is an eight-foot Pratt & Whitney measuring machine with which standard exact inch-rod gages have been made as required until the works have a complete set of whole-inch lengths up to 80 inches. These rods are used for adjusting caliper gages, shown in Fig. 10, all of which, except the micrometer heads, are home made.

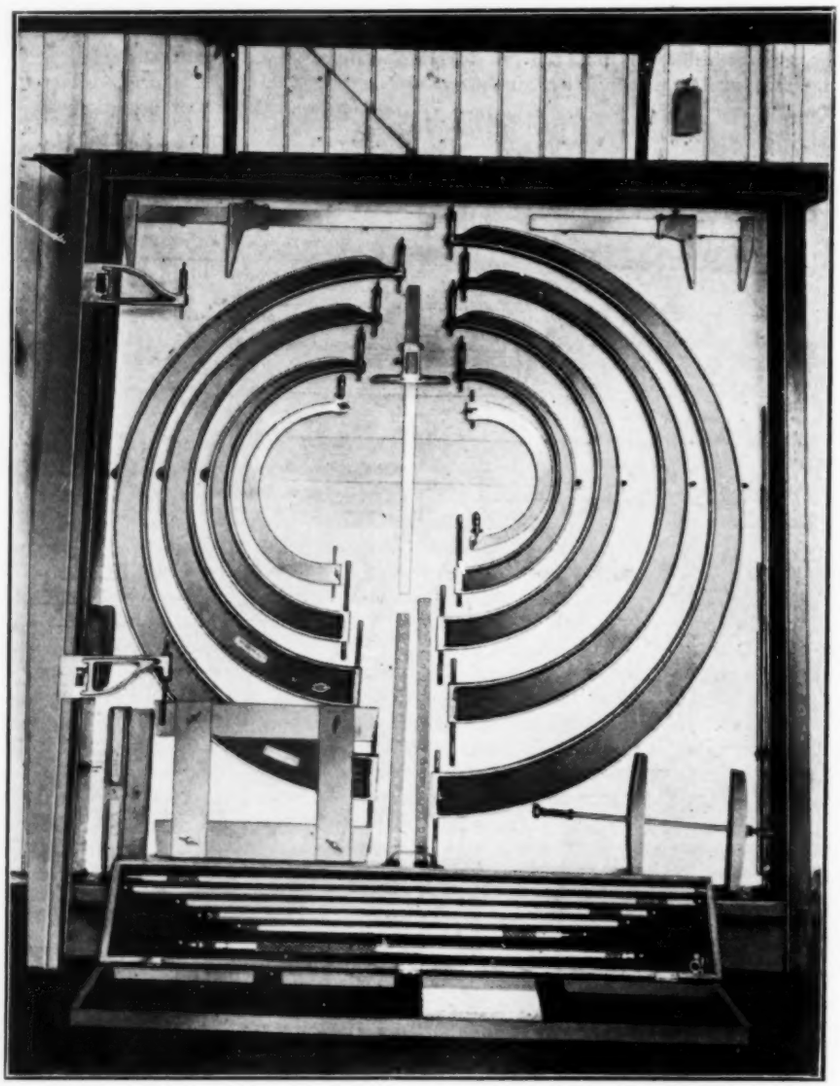


FIG. 10. INSPECTOR'S SET OF GAGES AND CALIPERS

RANGE OF THE CALIPERS

In making these calipers a good deal of care is given to obtaining exact alinement of the micrometer heads, and the anvil screw, but otherwise they are of everyday workmanship. The anvil screw has considerable range of adjustment and the calipers shown as having an I-beam section of yoke, which form a set by themselves, give thus a range from 10 to 40 inches by the following intervals:

No.	Inches.
1	10—14
2	14—18
3	18—22
4	22—26
5	26—30
6	30—35
7	35—40

SOME FEATURES OF CONSTRUCTION

The anvil screws have bastard threads, 10 per inch, though Mr. Thomas, to whom these gages are due, thinks that were he to make the set again he would make the pitch 20 per inch instead of 10. As these screws are used only for adjusting the instruments so that the micrometer heads will read zero for even inches, they are of ordinary lathe-cut accuracy only. The holes in the yoke ends for these screws are not threaded, but are bored a neat sliding fit, the nuts being half nuts only and arranged to be clamped to the screws or quickly disengaged by turning a nurled nut recessed into and projecting through the web of the I-section. This, of course, saves a lot of traversing of the screw when it has to be moved a considerable distance.

LIGHT YOKES

The yokes are made of zinc aluminum alloy, and are surprisingly light. The mixture is of 30 parts zinc to 70 aluminum, and the castings were made in the brass foundry of the works without difficulty. The largest frame weighs only nine pounds and the smallest but 2½.

For delicacy of action a caliper gage must, of course, be stiff. When made of steel or iron, however, increase in capacity involves rapid increase of weight and, while the stiffness is a necessity, the weight is objectionable because it dulls the sense of touch.

INSTRUMENTS EASY TO HANDLE

The lightness of these instruments is such that the largest sizes may be handled by one man with perfect ease, and, in connection with the appliances to be described, the gaging of the largest shafts is done by one man and, of course, with far greater satisfaction than would be possible with two men on opposite sides of the shaft being gaged. Those whose experience is limited to caliper gages of steel or iron can hardly appreciate the advantage which decreased weight gives. The calipers are handled with one hand and the contact of the measuring points with the piece being engaged is felt with the same delicacy and certainty that is customary with smaller work.

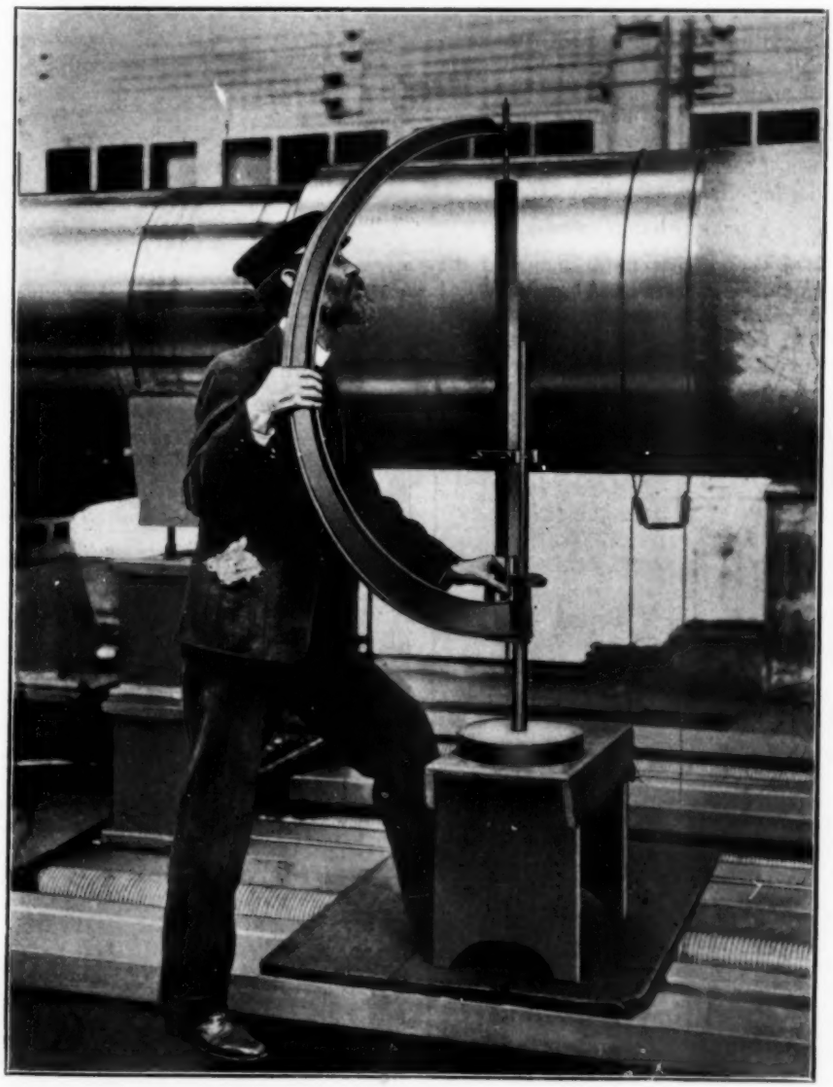


FIG. 11. ADJUSTING A LARGE MICROMETER CALIPER

MEANS OF ADJUSTMENT

The method of using these instruments is unique and is shown in Figs. 11 and 12. Fig. 11 shows Mr. Thomas in the act of adjusting the largest caliper. An end-measure rod surrounded by a wood case is shown supported in a vertical position by a stand having a heavy base. Clamped to the upright of the stand is a support for two helical springs, which support a stirrup having a hole through its center through which the anvil screw of the caliper is passed. The springs hold the anvil screw in gentle contact with the lower end of the end-measure rod, which in this case is 39 inches long.

SETTING THE MICROMETER

By adjusting the anvil screw the micrometer head is quickly made to read zero when the micrometer-head screw contacts with the upper end of the end-measure rod. Should the desired size be a few thousandths above the even-inch dimension for a force fit, or a few thousandths below for a running fit, or should it be desired to add any fraction of an inch to the length of the end-measure rod, the required amount is added by the graduations of the micrometer head, when, after clamping the head, the instrument is set for use.

HOW THE CALIPER IS USED

Fig. 12 shows the actual gaging of a 39-inch shaft in the lathe. Two light swing chains will be seen to surround the shaft and to support a pair of springs similar to those of the end-measure rod stand, these springs again supporting a stirrup which holds the anvil screw in contact with the shaft to be measured as the previous one held it against the end-measure rod. Held in this way, with the extreme lightness of the [illegible], the gaging may be done as shown and with the highest degree of satisfaction.

IMPORTANCE OF THE SUPPORT

The reader will not fail to note that all uncertainties regarding deflection of the instrument by its own weight are eliminated by its method of support. Its position is the same—vertical—when being adjusted as when being used, and the support is at the same point. Within the set of calipers which have been described two others will be seen which are made of sheet aluminum instead of alloy, and which by reason of their extreme lightness are found to be more sensitive than others. The one on the left is shown arranged for gaging bored holes, the yoke being very convenient for this class of work, as the instrument may be used with the boring bar still in place.

OTHER GAGING APPLIANCES

At the left is a cheap but very effective instrument for use in gaging such pieces as pistons for which the full depth of yoke is not needed. The beam is of wood

and the sliding heads of zinc-aluminum alloy, as with the full yoke form. In this instance the heads were first made of bronze, but their weight caused them to be discarded without being fitted up.

On the floor below the large case will be seen a set of Starrett inside micrometers, with a full outfit of extension pieces. These are of course used for gaging holes.

TOOLS FOR GAGING TAPER HOLES

Standing vertically on the bottom of the large case, and near the center, Fig. 10, are two carefully made strips of steel, each with an up-turned end and with a row of holes down the center spaced one inch apart. These are for use in gaging large taper holes in pieces for forced fits, for in the Westinghouse Machine Company's works many forced fits are taper, the taper used being approximately 1/16 inch per foot measured on the diameter. Fig. 13 shows the method of using these strips in connection with an inside micrometer, the taper being greatly exaggerated.

HOW THE HOLE IS GAGED

The measurements are not made perpendicular to the axis, but to one side of the bore. One point of the micrometer being held by a hole in the strip, the other is manipulated precisely as though the

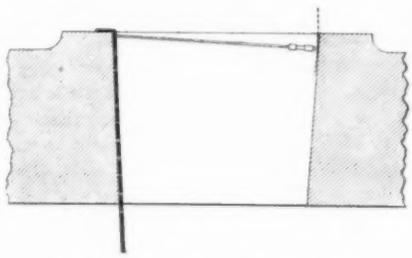


FIG. 13. GAGING A TAPER HOLE

bore were straight, as indicated by the dotted arc, and the frequent spacing of the holes in the strip enables the bore to be tested for uniformity of taper throughout its length. The dimension used measured in this way is the one given on the drawing as the true diameter, the microscopic difference between the dimension as called for and as made being obviously of no importance.

A SLIGHT CHANGE IN TAPER

Mr. Thomas has much simplified the gaging of these taper holes by a slight and otherwise unimportant change from the former taper of 1/16 inch per foot. With the miscellaneous lengths to which holes are made, the 1/16 per foot taper leads to awkward decimals for the diameter of one of the ends and for most of the intermediate inches. Thus a hole of 10 inches diameter at the large end and having a taper of 1/16 inch per foot will have the following diameters at successive inches of length when carried out to four places of decimals:

10.
9.9948
9.9896
9.9844
9.9792
9.9740
9.9688

IMPORTANCE OF THE CHANGE

By changing the taper to 0.005 per inch (1/16 inch per foot is equal to 0.005208 per inch) the values become:

10.
9.995
9.990
9.985
9.980
9.975
9.970

The change in the taper thus gives round figures for each inch of length, and the second set of figures is obviously much more easily read from the micrometer than the first; and, by subtracting from

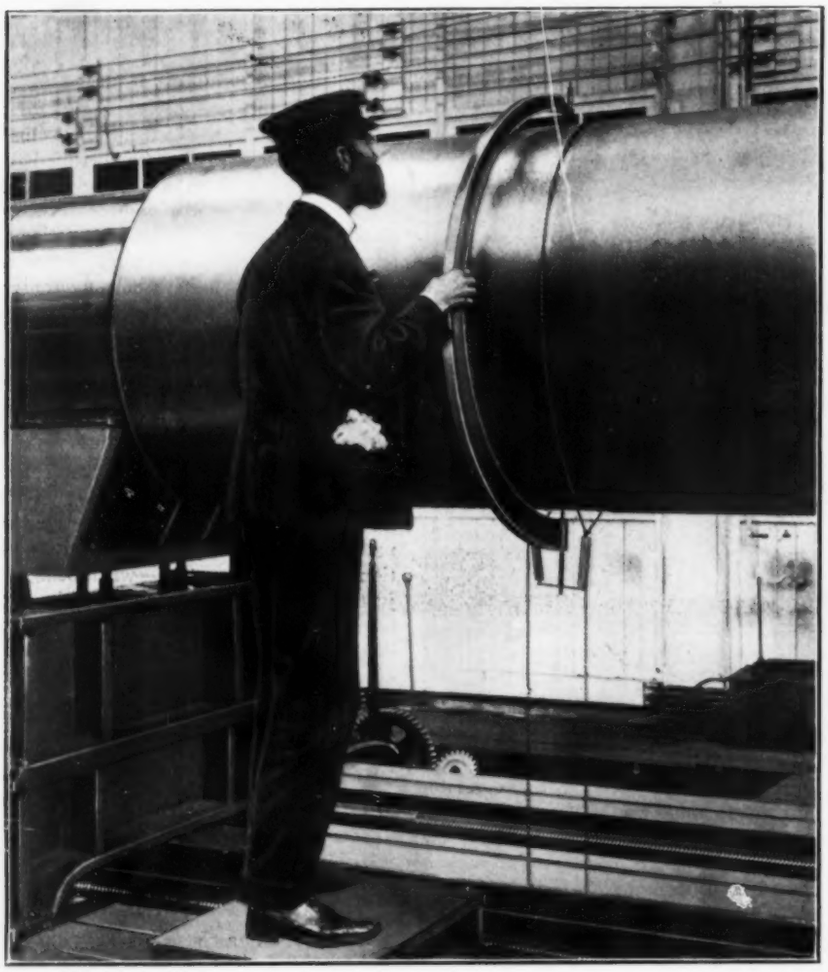


FIG. 12. GAGING A LARGE SHAFT

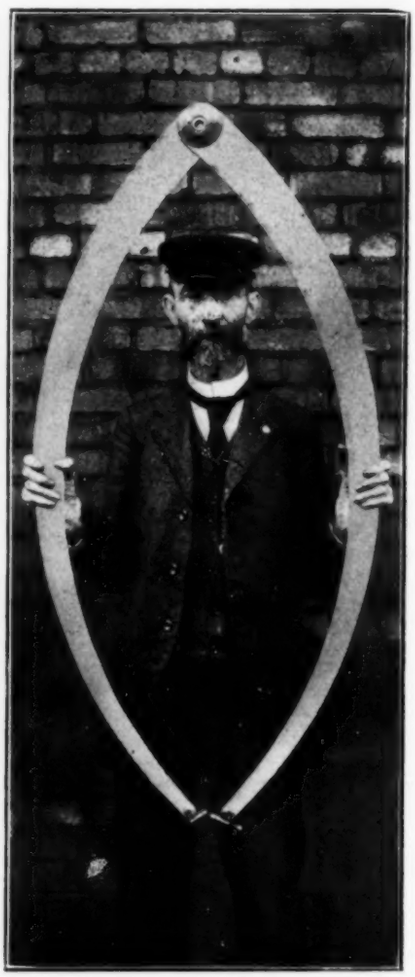


FIG. 14. A LARGE ARTICULATED CALIPER

the large diameter half as many hundredths as the piece has inches of length, the small diameter is obtained directly, whereas with a taper of 1/16 inch per foot the small diameter can, in most cases, be found only by calculation.

ONE ADVANTAGE OF TAPER FORCE FITS

One advantage of the taper force fit is not recognized as often as it should be.

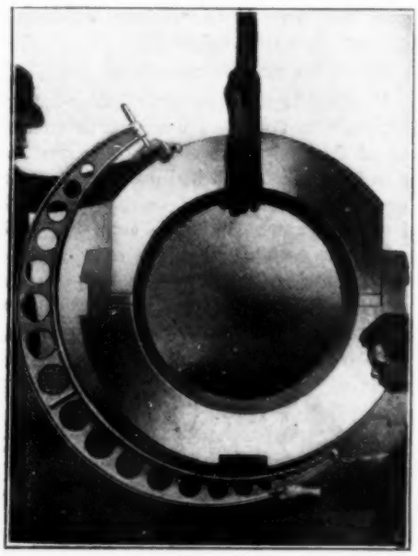


FIG. 15. A LARGE MICROMETER USED IN A BRITISH SHOP

With a parallel fit the holes can be compared only by gaging, whereas with the taper fit the plug may be centered in its seat and the two compared, the distance remaining for pressing home when the parts come to contact forming the best possible check upon both. Thus, with a taper of 0.005 per inch and an allowance of 0.01 for pressing, the plug should enter the hole within two inches of going home. The adoption of the 0.005-inch taper simplifies this relation as well as the gaging, as by using this taper the number of inches by which the parts should not go home when assembled is one inch for each 0.005 of pressing allowance.

A LARGE ARTICULATED CALIPER

Mr. Thomas finds, as others have found, that with the best outfit of gages the old-fashioned calipers still have their place and Fig. 14 shows such a caliper of large size and made of sheet aluminum. This instrument has a capacity over a full circle of 65 inches and its weight is but 7¼ pounds. Mr. Thomas calls it an articulated caliper from the construction of the contact ends. These are jointed to the jaws so as to present faces squarely to the work and one of the contact points is adjustable by a fine nurled-head screw, this screw being used for the fine adjustment of the instrument.

LARGE MICROMETER CALIPERS IN AN ENGLISH WORKS

Another set of large aluminum-zinc calipers, of which one size is shown in Fig. 15, may, in a sense, be said to be the descendants of those just illustrated, having been made and being in use in the Manchester works of the British Westinghouse Electric and Manufacturing Company, Limited.

CAPACITY AND DESIGN

No special novelty of the design is claimed. The sizes range from 12 to 48 inches, each size up to 36 inches covering 4, and above that size 6 inches each. The part of the design that consumed the most time was the adjustable tail spindle (anvil), as the shortcomings of the 10-threads-per-inch and half-nut clamp method had been noted. The method employed is much more expensive, but still not wholly satisfactory, the principal trouble with it being to secure for it proper use, which is part of the trouble with any tool that is used by many.

THE SPINDLE CONSTRUCTION

The tail spindles are tool-steel ground to 9/16-inch diameter, each clamped in a reamed 9/16-inch hole in the tail end of the micrometer frame by two 14—24 screws provided with nurled nuts, as shown in Fig. 16. This provision is ample with proper use. The tail spindle shown in Fig. 17 is hollow and provided with a 17/64-inch rod through the center, the hardened, ground and lapped end of which is the anvil. It was made 17/64 inch, because that is the diameter of the commercial micrometer screws used at the head of the micrometer frame.

METHOD OF TAKING MEASUREMENTS

The sketches will plainly show the construction of the tail pieces and the method of clamping. With this tail spindle ready adjustment to zero is secured. While these micrometers were being planed and made, no method of taking measurements with the larger ones had been decided upon. Before the first measurement was taken with a large one, the method shown in Fig. 15 with the anvil at the top had been decided upon, and it instantly proved its adaptability to the most delicate measurements; one 0.0005-inch variation in size being as readily detected as it would

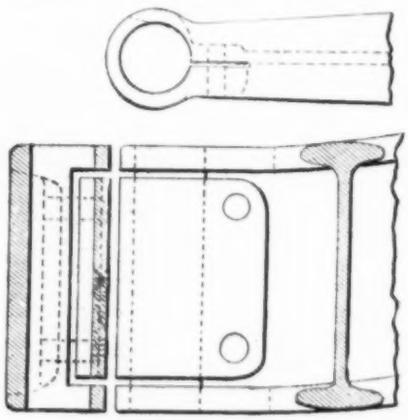


FIG. 16. ANVIL CLAMP FOR LARGE BRITISH MICROMETER

be with a one-inch or two-inch micrometer.

ADVANTAGES OF THE METHOD

The advantages of this method are obvious. The hand is at the point of contact; it is also at the screw to adjust it while feeling for contact; it is also not on the frame distorting it with warmth; but the greatest advantage lies in the fact that the micrometer hangs in stable equilibrium. The workmen say: "It comes up to the work itself," not wanting to leave the highest point of the work. The only care necessary to secure this advantage is to place the anvil at the proper hight, which hight, after the first few trials, is generally guessed correctly within an inch, the necessary adjustment taking but a few seconds.

SHAPE OF FRAME

In the half-tone, Fig. 15, the I-beam section and general outline of the frame will be seen. While there is a heavier section near the tail than the head, the fact that the instrument is to be used in

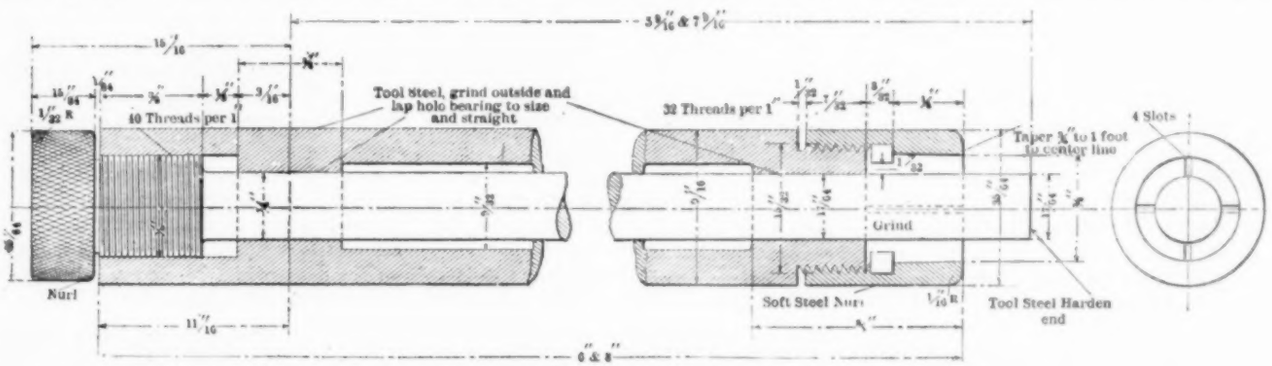

Tool Steel, grind outside and lap hole bearing to size and straight
40 Threads per 1"
32 Threads per 1"
Taper ¼" to 1 foot to center line
4 Slots
Grind
Nurl
Soft Steel Nut
Tool Steel Harden end

FIG. 17. CONSTRUCTION OF ANVIL OF LARGE MICROMETER

all positions kept out any tendency to follow the well known Thomas form.

Of course strict adherence to the principle of setting the micrometer while it is in the same position and supported in the same way that it is to be while taking measurements is necessary. Checking back on the measuring rod after taking an important measure is to be insisted upon.

THE SIMPLE SUSPENSION SCHEME

The suspended method shown in Fig. 15 has proved so satisfactory to its user that he feels it cannot be recommended too highly. He states that it not only gives better results than any other method known to him, but it requires no "tackle" except a helper's finger or thumb placed against the work at the right spot. While this method does not secure the possibility of one man taking a measure by himself, when using the large sizes, the helper's part is an inert part; any other support that could be readily attached to the work and movable would do as well as the helper's finger or thumb.

A LARGE MICROMETER GAGE IN ANOTHER SHOP

A machinist used to turning large eccentrics and similar work says in regard to the use of large micrometers, etc., that the workman should be equipped with tools quite as accurate as and more convenient than the inspector's, for without them his skill is robbed of most of its value. He continues as follows:

Of course, large outside calipers should be set and used when in the same relative positions, to insure that their weight does not change the setting. I can feel sore spots on my ribs as I write, caused by lying on the carriage, supporting the calipers with my left hand against the work, and feeling with my right for the spot where the calipers would just touch and no more. First I padded the lathe carriage, and later supported the templet so that in setting the calipers they would be supported by it. Then, when under a lazy, accurate and rapid-production influence, I made the gage shown in Figs. 18 and 19.

SETTING AND USING THE CALIPER

The templet is supported in a special clamp head that slides on a surface-gage standard, and when set on a level surface, lathe bed or carriage, the caliper gage is adjusted to the templet with the micrometer, then the thumb nut that clamps the lever at the bottom of the frame is slackened till it just holds the lever comfortably in position, and when the gage is passed over the work, when hanging vertically, the change in the position of the lever indicates the amount that the work is still too large. The counter weight is lifted off when it is not needed, and a longer vertical leg on the lever makes the gage available for much smaller work. While it is not intended for a standard for lengths, it is all right in making allowances for press or sliding fits.

STANDARD GAGES AND MICROMETERS IN THE SHOP

Chordal Visits a Machine Establishment and Shows the Proprietor a Few Small Tools He Requires to Produce Work to Standard Size

One of the most entertaining of Chordal's many instructive letters was based upon the use of standard measuring tools in the machine shop. Let us for a few moments turn back to his time and learn how he convinced a benighted manufacturer of the value of micrometers and other accurate measuring and gaging tools.

CHORDAL'S STORY

I have had a talk this week with Mr. Wyckoff in regard to the use of standard sizing tools in his shop.

"Why, Chordal, what are you talking about?" said he, after some other talk; "you have worked at the trade yourself enough to know there ain't any such thing as 0.001 of an inch. Once in a while some smart Aleck comes along from New England and lips off something about half a thousandth, and what not, but you know very well that hundredths are finer than men can work. Why, bless your soul, if I tell Frank to bore one hole two inches, and another hole 2.01, ten chances to one the small hole will be the biggest.

THE SKEPTICAL WYCKOFF

"Now, what's the use of talking about thousandths? There ain't any such thing in machine work. It's all Yankee blow. Just look here, Chordal; there is a scale graduated to hundredths; just look at those marks; you can't divide *them;* you can't even pick out the right one with calipers, let alone splitting them half a dozen or ten times. I tell you I worked thirty years at this trade, and I know how close a man can caliper. You tell me my two-inch shafting ought not to vary, the year around, 0.001 of an inch, and I tell you there is no way to help it, and, besides that, 0.001 don't make any difference in machine work, anyhow."

A TYPE OF YEARS AGO

Wyckoff is the type of the shop-owner generally met with. I wish you to understand this fully. He is not a bad man or a bad machinist or a bad manager. He is simply a common one, as distinguished from the extra fine men, etc. He said 0.001 was nothing; that, if a man made a driving fit and took 0.001 too much off, the drive would not be quite so tight, but no harm would be done; that 0.01 was fine business.

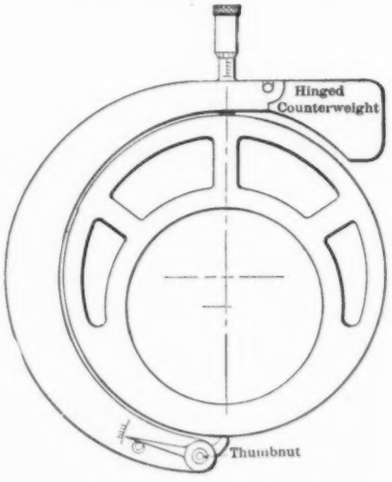


FIG. 18. MICROMETER GAGE

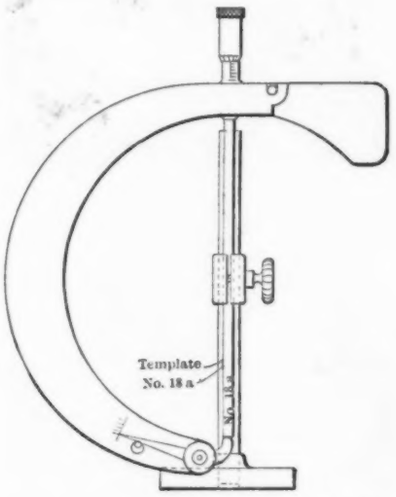


FIG. 19. SETTING GAGE TO TEMPLET

I was prepared to preach to Mr. Wyckoff, and had the examples in my pocket. I took out a little ½-inch plug and ring gage made by Pratt & Whitney.

APPRECIATION OF A GOOD JOB

Wyckoff's eye caught them. "Hello! Gosh, that's nice; ain't it? Pratt & Whitney, eh? Takes the Yanks to make nice things, don't it? My! ain't that a fine surface? How the deuce do they do that milling? Hardened, are they? How do they fix them up after they temper them?" etc., etc. Then he proceeded to put the plug in the ring. Won't go in. He turns the ring the other end to, of course, and tries again. Won't go in. Asks if it is make to drive. I tell him no. He works with it for ten minutes, and finally declares it won't go in without driving. I tell him to set the ring level and to push on the plug with one finger, steering it meanwhile to get it started straight.

THE GAGES GO TOGETHER

He does so, and after wrestling with it about three minutes the plug drops from

under his fingers and into the hole as slick as grease. He snatches it up in astonishment and works the plug back and forth in the ring. It tickles Wyckoff, and would tickle any appreciative mechanic to work such things together. The fit is perfect. It feels like glass fitting in velvet. No lumps, no taper, no nothing but perfect uniformity. Wyckoff works the thing and talks. "By Judas, but that's nice. Who'd a' thought that plug would go in that hole? And it ain't tight, either; is it? Just a nice fit; ain't it?" While he is talking he works the plug less and looks at it more. Pretty soon his countenance changes a little.

THE PLUG STICKS

He feels as though something was happening to the gage. He changes from his delicate finger grip to a broad and heavy hand grasp. The thing gets tighter. He bends his elbows and shows his teeth and twists and twists and twists, and the plug never moves in the ring. He looks puzzled and sold out. He knocks it endwise on the desk to drive it. It don't budge. He lays it down inquiringly. "Does heat do it? Does something expand? " I tell him no; that the minute globules of oil, kept in circular form by centrifugal force so long as he kept things in motion, flattened as soon as he stopped, and thus took the wheels away and left heavy contact sliding friction instead of rolling friction, etc.

THE GAGES ARE SEPARATED

I told him the plug would have to be driven out. We went out into the shop and found a hole to stick the thing through. We wanted something to drive on. Wyckoff suggested a prick punch, of course, and I suggested a wooden plug. We found one, and the plug was finally driven out. Wyckoff picked the gages up and put them right together again as nice as anything, and this time he was sharp enough to pull the plug out before he let the thing rest.

A LOOSE FIT

I now took from my pocket another plug apparently just like the first one. It had a flat place filed on the handle. Wyckoff took this plug and stuck it in the ring. It was loose; it shook in the ring; he could see big daylight through the fit. He said there was nothing nice about that fit. There was nothing charming about it, like there was in the other. Then he tried the big plug again, then the little one, and then the big one again, seriously and studied. "Now," says I, "Wyckoff, you know how those two plugs fit in the ring; tell me how much difference there is between the two plugs."

A GUESSING CONTEST

He looked and tried again, and squinted, and looked wise, and thought solemnly of the graduation on a scale, and then said: "Well, I think it's about—well, say—I should say—well, just about—say 0.01 of an inch—no—well, yes—wait till I call Port in—I say about 0.01, and we'll see what Port guesses." Port comes in and goes through the whole process under Wyckoff's directions. Pratt & Whitney ought to see the show. Port, after the process, puts his figure at 1/128 of an inch; that is, he mentally splits 1/64.

OTHER PARTICIPANTS

Then he must call in Gus, who is the crack lathesman of the shop, and then Mac, who is a smart chap, and then George, a fine New England workman, who is turning mill pulleys. The exhibition is over and the guesses are all in. All are mightily interested. Gus says 1/64 scant; Mac says 0.02; and George shakes the loose plug two or three times, while his thought shakes in unison, and he guesses at half a thousandth. He has handled gages before, and has done some blowing before, and the laugh is on him.

WYCKOFF'S LESSON

Then Wyckoff wants to know what the real difference is. I tell him it's 0.001 of an inch, and all look incredulous. "Why," says Port, "that would spoil any kind of work—yes, half of it would—yes, by George, the fifth of it would. You don't mean to say that's only 0.001 of an inch?" I assured him I did; that I had these gages made to show Wyckoff the real value of a thousandth; that this showed that the men in the shop were working and must work closer than thousandths every day.

ANOTHER SURPRISE

Wyckoff said he was completely beat. Wouldn't have believed it; but just for a joke he would like to give a quarter to see how much 0.01 was. I quickly pocketed his quarter and produced the third plug from my pocket, 0.01 of an inch smaller than the one which fitted. Wyckoff tried this one and said: "Why, Mr. Chordal, I would have sworn that was a full 1/32 smaller than the hole. I had no idea I worked at as fine a business as I do. If that middle plug is only 0.001 small, I have worked to quarter-thousandths myself, when I worked at all, only I didn't know it."

THE PROPRIETOR'S QUANDARY

He was interested and got a pair of calipers. "Yes, there's a big difference; enough to spoil any kind of a fit; but, see here, Chordal, try these calipers on this nice scale; you or no other man could tell whether those calipers were set at an exact half inch, or 0.001, or even 0.01, large or small. Those gages are surprising, but I can't caliper any closer than before. I see now that a man can work, or ought to work, way inside of the thousandths; that one piece of line shafting 0.001 smaller than another won't fit the same pulley at all, at all; but, since you have commenced, I want to know how it is to be helped.

A PERTINENT QUESTION

"How are you going to fix things so the men can set their calipers any closer to the size ordered than they usually do? If I go out and tell Gus to turn a piece exactly a half inch, I don't know whether it would fit in that ring like the big plug, or like the little one, or whether it would go in at all or not; and I know mighty well if I got Gus to turn one nice piece, and got Frank to turn another nice piece, they would certainly vary in size as much as that little plug does from the bigger one."

THE MICROMETER IS INTRODUCED

I now went down in my pocket again and produced a Brown & Sharpe micrometer caliper. This well known little tool was a new one on Wyckoff. I explained that the screw was 40 threads, and that consequently each full turn of the thread made 1/40 or 0.025 of an inch; that the turning sleeve had 25 divisions on it, and that consequently turning the sleeve one division would open the caliper 1/25 of 0.025, which would be 0.001 of an inch; that the divisions may be easily divided by the eye so that half and even quarter thousandths can be measured; that the line of exposed graduations on the hub were fortieths of an inch or 0.025 each.

SOME EXPERIMENTS

Wyckoff saw it all in a minute and commenced calipering hair and twist drills, and his little finger and every other thing he could pick up. "Now," said I, "set that caliper at 20/40 and the sleeve zero on the hub zero line." He did so. I handed him the big plug. "By George, Chordal, that fits to a dot, don't it?" said he. I told him to turn the sleeve one division and thus close the caliper 0.001 and then gave him the middle plug. "Got it again," said he. Then he turned the sleeve ten divisions and the smallest plug fitted exactly.

WYCKOFF WANTS SOME GAGES

"Now," said I, "you see that this does more than caliper; it measures. You can see that Gus and Frank could get two pieces nearly alike by the use of such a tool. Here is the poor little thousandth you have denied the existence of brought right to your hand and shown to be big and important." "Chordal," said Wyckoff, "I want those plug gages." I told him he couldn't have them. Told him to send and get a set and not lock them up in the safe when he did get them either, but to let the boys have them to take home and fool with.

THE MICROMETER CHANGES HANDS

"All right," said he; "but can I get that caliper business, too?" "Yes," said I, "you can get all you want. They only cost five dollars, and you will find lots of New England workmen using them. I am surprised that you never saw one before." (I was not surprised, though, for I knew no man by the name of Wyckoff ever did see one.) Wyckoff said he would give me $5 and a pocket full of cigars for this caliper.

I took the cigars only, and gave him the caliper. No colporteur ever felt the blessing of giving more than I did.

SOME FURTHER POINTERS

Wyckoff asked me if they didn't make big ones; said a man couldn't do lathe work with this size. I told him I wasn't half done with him yet; that these calipers were for nice and accurate measuring, and not for calipering. Said I: "Suppose you had a pair of outside calipers set nicely to say two inches, and fitted to a two-inch plug like these little ones; wouldn't such a caliper keep your two-inch work uniform and save all the time of setting calipers to scales?" Yes; he thought it would; and then suddenly said he saw the trick exactly. Make a lot of solid calipers and let the boys use them. I told him he had hit it exactly, only he would be foolish to try to make them. He could buy them for half, yes a third, the cost of making them.

SNAP GAGES AND PLUGS

I went down in my pocket again and brought up a caliper gage, two inches. Wyckoff said if he didn't know my missionary traits, he would take me for a drummer with a full line of samples. "Now," said I, "here's your rig. This caliper is steel, and hardened. It is accurate and can be kept so. One end is male, and is not liable to lose its size. The other will lose size, and you must have something to size it back to. Get a set of plugs, or their equivalent, and never use the plugs for any purpose whatever, except to size the calipers as they wear big. When you get these tools, lock the correcting gage up, and hang the calipers on a board, and place them in the custody of a smart apprentice. Make him the toolkeeper. He will see them kept in place and to size, and some day you will have a tool-room without knowing it."

Number of Specimen	Diameter of Spindle	Kind of Joint	Force necessary to Start Joint	Force per Square Inch	Kind of Test
	Inches		Lbs.	Lbs.	
1	1.001	Force	1000	318	Tension
2	1.001	Shrink	5320	1695	"
3	1.001	Shrink	5820	1853	"
4	1.001	Shrink	2200	700	Torsion
5	1.0015	Force	2150	685	Tension
6	1.0015	Force	2200	700	Torsion
7	1.0015	Force	2800	892	"
8	1.0015	Shrink	7200	2290	"
9	1.0015	Shrink	9800	3118	"
10	1.002	Force	2570	818	Tension
11	1.002	Shrink	7500	2385	"
12	1.002	Shrink	8100	2580	"
13	1.002	Force	4200	1335	Torsion
14	1.0025	Force	4000	1272	Tension
15	1.0025	Shrink	9340	2974	"
16	1.0025	Shrink	9710	3090	"
17	1.0025	Force	4600	1465	Torsion
18	1.0025	Shrink	13800	4395	"
19	1.003	Shrink	17000	5410	"

TABLE I. RESULTS OF STRENGTH TESTS OF SHRINK AND FORCE FITS

EXPERIMENTS WITH SHRINK AND FORCE FITS

Results of a Series of Tests made at an Engineering School—Further Experiments in a Machine Shop to Determine the Behavior of Cast-iron Disks when Forced on a Mandrel

These experiments as carried out in the mechanical engineering department of the Alabama Polytechnic Institute consisted in shrinking and forcing steel spindles into cast-iron disks, and afterward pulling some of them out, and twisting the others in the holes.

THE DISKS

A number of sound gray-iron disks, about six inches in diameter by one inch thick, with a boss on one side about two inches in diameter by ¼ inch projection, were secured. It was specified that these disks should all be molded by one man and poured from the same ladle of iron, in order that they should be as nearly uniform in texture as possible.

A ⅞-inch hole was drilled in the center of each of these disks and they were then chucked in a lathe and bored out to 63/64 inch and faced. They were then reamed, first with an ordinary one-inch fluted reamer about 0.002 inch under size, and finished with an adjustable reamer to one inch with an error believed not to exceed 0.00025 of an inch.

THE SPINDLES

The spindles were made from a good quality of machinery steel 1¼ inches in diameter. The end for a distance of 1¼ inches was turned down to a diameter of 1 1/32 inches, and a shallow groove ⅛ inch wide was cut next to the shoulder to allow the emery wheel in the grinding operation to clear at the end of its travel. They were then put on the universal grinding machine and carefully brought to diameters varying by 0.0005 inch, as follows:

Number of spindles.	Finished diameter.
4	1.001 inches.
5	1.0015 inches.
4	1.002 inches.
5	1.0025 inches.
1	1.003 inches.

THE MEMBERS ARE PUT TOGETHER

The end for ⅛ of an inch was slightly tapered to enable the spindle to readily enter the hole; the actual surface in contact being thus reduced to one inch in length. About half these spindles were then forced into the holes in the disks by means of a testing machine, care being taken to insure a straight and true entrance, the maximum pressure required in each case being noted. The remainder of the spindles had the disks shrunk on; the latter being heated only enough to admit the spindle. Some of each sort were then tested by pulling the spindle out of the hole, and the others by twisting the disk on the spindle.

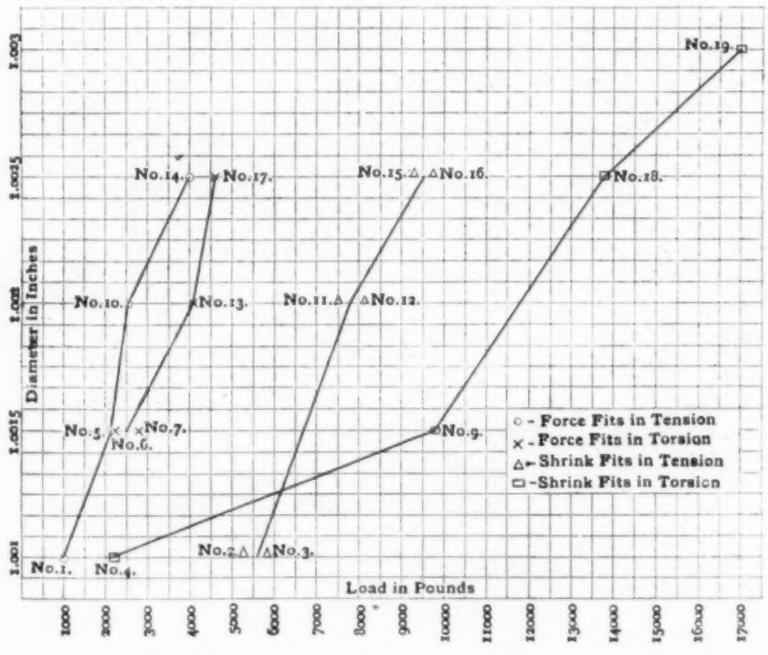


FIG. 20. DIAGRAM SHOWING RELATION OF STRENGTH OF VARIOUS FITS

THE TENSION TESTS

In the arrangement of the parts for the tension tests, a disk similar to those previously described, except that it had a larger and longer boss, was threaded with a 1½-inch standard thread, to which was fitted a spindle. This, as well as all of the test disks, had four bolt holes drilled through the flange. The test pieces were then bolted one by one to this threaded disk, put in the testing machine, the spindle pulled out and the maximum pull noted.

THE TORSION TESTS

In testing the force necessary to turn the disk on the spindle, the latter was placed in a lathe between centers. A cast-iron arm was bolted to the disk and supported in a horizontal position by a knife edge having a bearing 10 inches from the center of the disk. The support for the knife edge was a piece of scantling resting on a platform scale. A heavy pipe wrench on the spindle with a "foot-ball man" at the handle furnished the necessary turning force. In Table 1 the figures show the forces reduced to the circumference of the spindle in order to make them comparable with the tension specimens. It should be remembered that all the holes were one inch in diameter and 1¼ inches long, the variation in diameter being made in the spindle.

SHRINK FITS MUCH STRONGER THAN FORCE FITS

It will be noted that the shrink fits are quite uniformly about three times as strong as the force fits of corresponding size, both in tension and torsion. The force fits were made without lubrication other than the small amount of machine oil adhering to the spindle on account of having been wiped with oily waste after grinding, to prevent rusting. The spindles and holes were found to be smooth, and in good condition after the tests. The maximum force was required to start the spindle. After movement had once occurred between the two surfaces, a much smaller force was required to start it a second time. No. 19 test piece was tried in torsion up to the limit of the scales without movement.

RESULTS PLOTTED

The figures from the table, with the exception of No. 8, were plotted on coördinate paper, and show some interesting characteristics. (No. 8 was omitted because it was known to be too low, the beam of the testing machine being at rest at the top of its travel at the time the joint failed.) These points naturally resolve themselves under four heads: First, force fits under tension; second, force fits under torsion; third, shrink fits under tension; fourth, shrink fits under torsion. By reference to these curves in the diagram, Fig. 20, it will be observed that the general direction or slope of the curve is about the same for the first three, but for the fourth, the angle made by the curve with the vertical axis is about 30 per cent. greater. This would seem to indicate that the strength increases more rapidly with the diameter under these conditions.

AN IMPORTANT QUESTION

The question naturally arises as to how far these conditions would hold, and an interesting field for further investigation is opened up. The maximum tangential effort of 17,000 pounds obtained in the tests would, with a coefficient of friction of 0.2, give a normal pressure of 85,000 pounds, or 27,070 pounds per square inch—a pressure well within the crushing strength of the metals employed. With greater difference between the diameter of spindle and hole, it might be necessary to force the spindle into a heated disk.

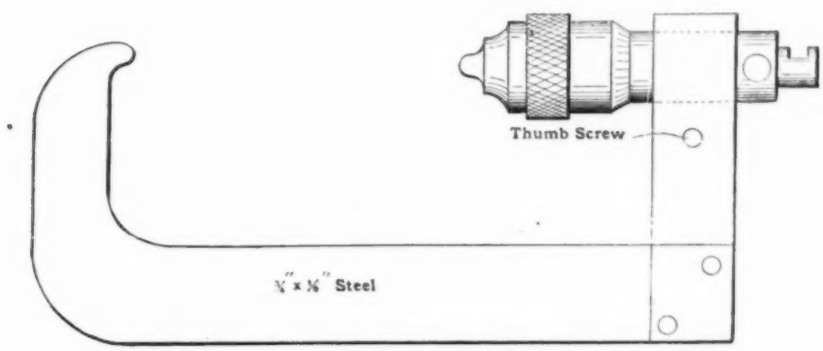


FIG. 21. CALIPER

It seems evident from these experiments that the shrink fit is the better of the two, but in practical work it is not always the best way, but the "good enough" way that is sought. If, therefore, the force fits are good enough and can be made more cheaply than shrink fits, they will be used in every case.

A PRACTICAL EXAMPLE

Let us assume that the pressure per square inch of bearing surface between the disk and the spindle would remain constant for larger sizes, the allowance per inch in diameter remaining the same. Let this allowance be 0.002 inch per inch in diameter, a fair average value as used in practice. Take an engine shaft five inches in diameter, upon which a crank disk is to be forced. The length of the hole in the disk should at least equal the diameter, say five inches. Then the area of the surface in contact would be $3.1416 \times 5 \times 5 = 78.54$ square inches. Referring to the table we see that specimen No. 13 is 1.002 inches in diameter, and in other respects complies with the conditions assumed above. It required 4200 pounds to start the joint. Then $4200 \div (3.14 \times 1) = 1337.5$ pounds per square inch of surface in contact. Now $1337.5 \times 78.54 = 105{,}047.25$ pounds, the force acting at the surface of the shaft required to start the joint.

THE EFFORT REQUIRED TO START THE JOINT

Now, a five-inch shaft would not be likely to be found on an engine with a cylinder larger than 12 inches in diameter by 18 inches stroke. Then 105,047.25 multiplied by 2.5, the radius of the shaft, and divided by 9, the radius of the crank, gives 29,179.8 pounds acting on the crank pin at its point of maximum turning effort required to move the joint. With a pressure of 100 pounds per square inch on the piston, this would require a piston of 291.8 square inches area, whereas a 12-inch piston has only 113 square inches, thus giving a factor of safety of 2.6 nearly. This would probably be too small to satisfy the engine builder for cranks, pistons and the like, but there are many other places in mechanical construction for which the factor would be ample.

FACTOR OF SAFETY INCREASED BY SHRINK FIT

If, however, the crark should be shrunk on, the joint according to our table would be from two to three times as strong, and the factor of safety would rise to a point that should satisfy the most exacting. A comparison of the cost of making a shrink fit with that of making a force fit with the keying necessary for safety would determine in any particular case which one to use.

In conclusion, the author acknowledges the incompleteness of the tests, the men who carried on the work being young and inexperienced in the production of work having a high degree of accuracy, and as a consequence many of the specimens prepared were rejected before being used in the tests.

VALUE OF THE EXPERIMENTS

While it is true that the experiments described above do not cover a range as extensive as would be desirable, and the author does not pretend that the one-inch fits experimented with show with absolute certainty what larger shafts would do under the same conditions, the inference is a fair one that these tests do give a pretty good idea of what may be expected. Perhaps if tests had been made with say ½-inch, ¾-inch and ⅞-inch shafts as well as with one-inch, a somewhat clearer idea would hav. been obtainable from them.

THE PRACTICE OF SOME LARGE CONCERNS

It will be remembered that the establishment of A. Bollinckx, of Brussels, depends almost entirely upon forced and shrink fits, without keys or set screws, in building Corliss engines, and Lane & Bodley, of Cincinnati, have also for several years been depending upon press fits for engine cranks, with entire success. A record of their observations on such fits is presented in another part of this supplement.

SOME SHOP EXPERIMENTS

A series of experiments, as described below by the man who made them, were

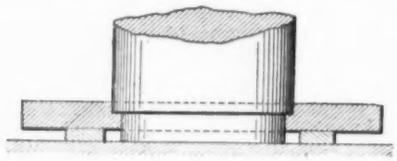


FIG. 22. THE MANDREL AND THE DISK

conducted in an Ohio shop with appliances sketched in Figs. 21 to 29, inclusive, to determine the effect upon the outside diameter and bore of cast-iron disks when pressed onto arbors.

THE STORY OF THE TESTS

I have always regarded the elastic limit of materials used in the construction of a machine as a sort of dead-line which it is never safe to approach closely, to say nothing of ignoring. There appears to be one exception to this rule, i.e., the shrinking or pressing fits. It should be remembered that the tension of the hub of a wheel, when shrunk or pressed on, is greater at the surface in contact

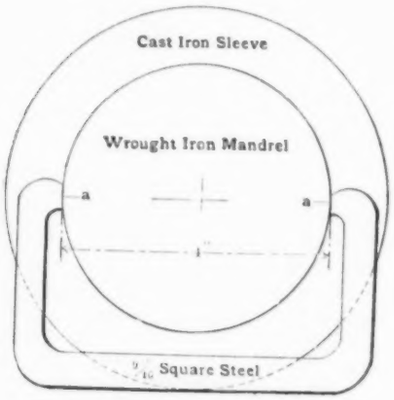


FIG. 23. THE GAGE FOR THE MANDREL

with the shaft than at its outside diameter, and it is probably this condition that makes the higher allowance safe in practice.

THE MANDREL AND THE DISKS

In order to see how cast iron behaved under such conditions, I had a mandrel made of wrought iron, four inches in diameter and about a foot long. One end was turned down to 3½ inches, about two inches long, and the other end reduced about 0.004 inch, 1⅛ inches in length. Then two cast-iron disks were made, both one inch thick; but the diameter of one is six inches, of the other eight inches. Both were supposed to be bored 0.004 inch less than the mandrel. The measurements were made as follows: Outside calipers were used to get the sizes of the mandrel. One of Starrett's No. 120 inside micrometers was set to the calipers, then shortened 0.004 inch, and the disks bored to the micrometer. The outside diameter of the eight-inch disk was then taken with calipers, and the micrometer set to the caliper.

THE MANDREL IS FORCED IN

The disk was then put on the mandrel, and both put in the testing machine, and the mandrel started into the disk till the end reached the top of the table, as shown in Fig. 22, the object being to insure the mandrel's being square with the face of the disk. The mandrel was then entered into a sleeve that was faced on each end and bored to slide over it. Then with a pressure of 8900 pounds the mandrel was forced into the disk about five inches.

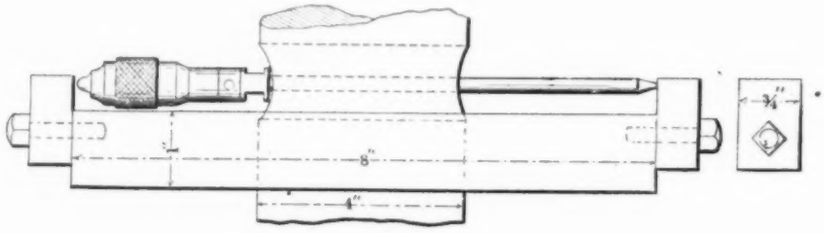


FIG. 24. MEASURING EXPANSION OF DISK

Then the disk was calipered to see how much it had expanded. And right here the fun began, for it was soon found that accurate measurements could not be made with outside calipers and inside micrometers in combination for such work.

A CHANGE OF DISKS

The eight-inch disk was pushed off and the six-inch forced on with a pressure of 5600 pounds. The result was no more satisfactory with the six-inch than with the eight-inch. All that was known was that the disks were larger when on the mandrel than when off, and that they were larger after having been pushed on and off than before. Another eight-inch disk was made and a system of measurement employed by which the outside diameter of the disk could be determined to 0.0001 inch, and the difference between the diameter of the mandrel and the hole in the disk to 0.0005 inch or less.

A SPECIAL GAGE

A gage was made for the mandrel of 9/16 inch square steel, as shown in Fig. 23. The bottom side of the gage was surfaced, and then the surfaces *a a* were scraped and rubbed down till they were parallel, and would just touch the mandrel when both were at the same temperature. The top of the sleeve, spoken of before, made a very convenient guide for the gage to slide on while the surfaces were being worked down to fit the mandrel. It was then found that the mandrel was not quite round.

BORING THE DISK

No trouble was experienced in setting the micrometer to this gage; but setting a lathe tool to bore a four-inch hole to within 0.0005 inch is quite another thing. However, the disk was bored 0.0045 inch smaller than the mandrel without a possibility of varying as much as 0.0002 inch either way. It should be stated that the micrometer was not graduated to read closer than thousandths; so the barrel was chucked in a lathe, and nine longitudinal lines put on the back to correspond with ten divisions on the thimble.

PROVISION FOR ACCURATE MEASUREMENT

To determine the change that took place in the outside diameter of the disk two small lugs, projecting ⅜ inch above the face, and opposite each other, were fastened on with ¼-inch cap screws. The micrometer was wrapped with paper to protect it from the heat of the hands and breath, and ample time was taken to adjust it accurately. The disk was then put on the mandrel and pressed on with a pressure of 9300 pounds, up to the hole in the mandrel to put the micrometer through, as indicated by Fig. 24.

CHANGE IN BORE AND EXTERNAL DIAMETER

No change of shape could be detected in the disk, except its diameter, which was carefully measured and found to be 0.0016 inch larger than before. The mandrel had expanded the inside of the disk 0.0045, as no compression could be found in the mandrel. This ratio of internal to external enlargement would indicate that a 10-inch hub for a four-inch shaft would be as large as there would be any use in making it with that coefficient of expansion. The method of determining this diameter (10 inches) is shown in Fig. 25. It required 11,000 pounds to start the disk back on the mandrel, and when off it was found to be 0.001 inch larger internally, and 0.0005 larger externally than before being pressed on.

TEST WITH A STEPPED MANDREL

The disk was then forced on a mandrel made as in Fig. 26. The various diameters and pressures required to force the disk on are shown on the sketch. It

was thought that the largest diameter of mandrel would burst the disk, but it stood it O. K. The hole shown in the top of the mandrel was made for the micrometer to pass through when getting the diameter of the disk before it was pressed off, which was found to be enlarged 0.015 inch, while the inside was expanded just 0.02 inch larger than it was bored, indicating, as will be seen by referring to Fig. 27, that a 20-inch hub would be required for a four-inch shaft if a coefficient of expansion of 0.005 is to be used. After being pressed off, the disk was 0.004 larger outside and 0.009 larger inside than it was originally.

HOW THE MICROMETER WAS APPLIED

In making the measurements, the micrometer was first lengthened till it would lie at an angle, as in Fig. 24. Then after being left for, say, 20 minutes, to come to "thermal equilibrium" with the disk, the high end had not dropped. The micrometer was shortened and given another opportunity, and the operation was repeated till it did drop. Center lines were drawn on the lugs and the ends of the micrometer kept to them.

It will be noticed that attention has been paid in the above to compression of the arbor by the disks, and to satisfy myself (and the editor) on this point, I made some experiments as follows:

GAGING THE ARBOR

The disk was pressed on the large arbor with 23,300 pounds. Then a gage was made to fit the arbor as close to the disk as possible, with almost knife-edge bearings, as shown in Fig. 28. The temperature of the room was 60 degrees, and there is no reason that I can see why the mandrel, disk and gage should not have been the same. The disk was now pressed off, and the mandrel set up where it could be gaged in the same place, and with similar supports for the gage. With the temperature of the room as before, the gage was put in a bucket of water having a temperature of 130 degrees (by same thermometer). Then, without waste of time, the gage was applied and was found to be too big for the mandrel, and continued so to be so until the temperature of the water and gage was reduced to 120 degrees.

CONCLUSION

The gage was made of an old circular saw, close to 3/32 inch thick, and had an average width of about one inch. If the difference in the temperature of the gage (see Fig. 29) and arbor was 60 degrees, as I am sure it was, then the compressure of the shaft would be 0.00033 inch. It seems to me this method ought to give accurate results, and the compression of the arbor, I suppose, may be assumed to be proportional to the force required to press the disk on the arbor, say 0.0001 inch compression for each 7500 pounds force for other allowances.

LIMITS FOR PRESS AND RUNNING FITS

The Practice of Several American and European Firms of Machine and Gage Manufacturers

A British firm of engineers, Joseph Adamson & Co., of Cheshire, England, in order to establish suitable limits for gages for their own work took half a dozen of their motor spindles that had just been turned and finished in the ordinary way to cylindrical gages of the usual Whitworth pattern, and measured them at different points on the various turned surfaces. There were four different diameters, two being running fits and two being keying fits.

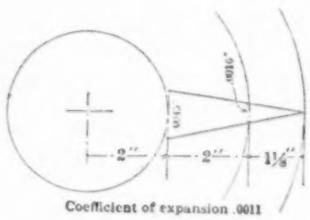


FIG. 25. INTERNAL AND EXTERNAL EXPANSION

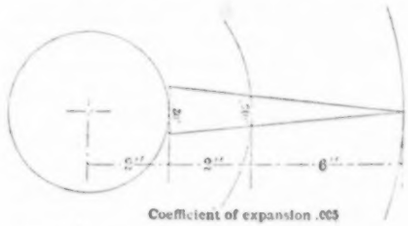


FIG. 27. INTERNAL AND EXTERNAL EXPANSION

WHERE THE MEASUREMENTS WERE TAKEN

To ascertain at the same time whether the spindles were round, two measurements were taken at each point on the spindle chosen, the second diameter being at right angles to the first. When these results were tabulated and the differences between the highest and lowest of each of the diameters was ascertained, it enabled them to decide what would be suitable limits for this class of work; and the information thus gathered may be of assistance to others who are interested in the same subject. Table 2 is reproduced from a print from their record.

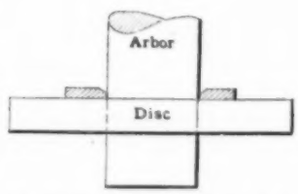


FIG. 28. SHOWING THIN EDGES OF GAGE

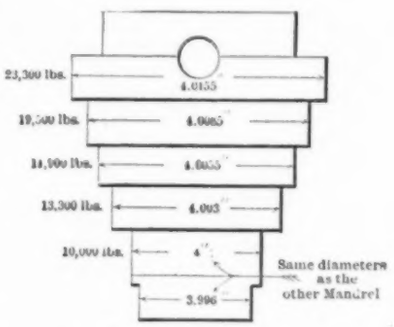


FIG. 26. THE STEPPED MANDREL

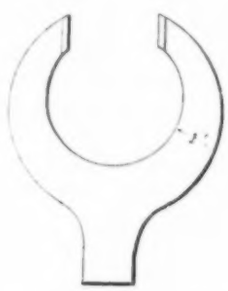


FIG. 29. OUTLINE OF GAGE

Referring to the sketch of the spindle at the top of the table, it should be explained that diameters were measured at each of the points indicated on the sketch by letters *A*, *B*, *C*, etc., and it will be seen that two points were taken on the shorter surfaces and three on the longer one. The running fits are *A B* and *H J*, and these have been filed after turning. The driving fits are *C D E* and *F G*, and are as the tool left them.

THE MAXIMUM VARIATION

The maximum difference is on the bearing *A B* and the explanation is that, owing to the collars, the turner was not able to apply his external cylindrical gage; but it will be noticed even here that, if spindle No. 5 is thrown out, the maximum variation on the other five spindles is only 0.0015 inch. It is perhaps unnecessary to add that these spindles were not turned specially for this test, as instructions for measuring them originated after they were finished.

LIMITS AND ALLOWANCES IN WORK-SHOP GAGES

The limit gages developed and manufactured by the Newall Engineerng Company, of London, England, are well known to our readers, these tools having been illustrated some time since in these columns. In connection with this gage sys-

tem the firm collected the practice of the leading English, continental and American engineering concerns relative to allowances for different kinds of fits and prepared a table which is the average of all the data received, every point included being covered by the practice of some prominent establishment. These limits and allowances thus arrived at for shop gages are given in Table 3, which is self-explanatory.

THE PRACTICE OF A NEW YORK ESTABLISHMENT

By the courtesy of the C. W. Hunt Company, we are enabled to publish the accompanying tables, giving the practice of that company in limits of workmanship for various kinds of work, as well as in allowances for press and running fits.

PARALLEL PRESS, DRIVE AND CLOSE FITS

Table 4 gives all the particulars for press, drive and close or hand fits for parallel shafts ranging between one and ten inches in diameter. In accordance with general practice, the holes for all parallel fits are made standard, except for the unavoidable variation due to the wear of the reamer, the variation from standard diameter for the various kinds of fits being made in the shaft. This variation is, however, not positive, but is made between limits of accuracy or tolerance. Taking the case of a press fit on a two-inch shaft, for example, we find that the hole—that is, the reamer—is kept between the correct size and 0.002 inch below size, while the shaft must be between 0.002 and 0.003 inch over size. For a drive or hand fit the limits for the hole are the same as for a press fit, while the shaft in the former case must be between 0.001 and 0.002 large and in the latter between 0.001 and 0.002 small.

PARALLEL RUNNING FITS

Table 5 gives in the same way the allowances for parallel running fits of three grades of closeness. The variations allowed in the holes are not materially different from those of the preceding table, but the shafts are, of course, below instead of above the nominal size.

TAPER PRESS FITS

Table 6 relates to a special and highly interesting feature of the Hunt company's practice. While Table 4 includes allowances for parallel press fits, the preferred practice for press fits at these works is to make them taper, the taper used being the Hunt standard of 3/16 inch in diameter for each foot in length. With fits of

Nominal Diameters . .	½″	1″	2″	3″	4″	5″	6″
Over size	.00025	.00050	.00075	.00100	.00100	.00100	.00150
Under size	.00025	.00025	.00025	.00050	.00050	.00050	.00050
Margin	.00050	.00075	.00100	.00150	.00150	.00150	.00200

LIMITS IN PLUG GAGES FOR STANDARD HOLES

Nominal Diameters .	½″	1″	2″	3″	4″	5″	6″
Mean	.00075	.00175	.00350	.00525	.00700	.00900	.01100
High	.00100	.00200	.00400	.00600	.00800	.01000	.01200
Low	.00050	.00150	.00300	.00450	.00600	.00800	.01000
Margin	.00050	.00050	.00100	.00150	.00200	.00200	.00200

ALLOWANCES—OVER STANDARD—FOR FORCE FITS.

Nominal Diameters . .	½″	1″	2″	3″	4″	5″	6″
Mean	.000375	.000875	.00125	.00200	.00250	.00300	.00350
High	.00050	.00100	.00150	.00250	.00300	.00350	.00400
Low	.00025	.00075	.00100	.00150	.00200	.00250	.00300
Margin	.00025	.00025	.00050	.00100	.00100	.00100	.00100

ALLOWANCES—OVER STANDARD—FOR DRIVING FITS.

Nominal Diameters . .	½″	1″	2″	3″	4″	5″	6″
High	.00025	.00050	.00100	.00150	.00150	.00200	.00200
Low	.00075	.00100	.00150	.00200	.00250	.00250	.00250
Margin	.00050	.00050	.00050	.00050	.00050	.00050	.00050

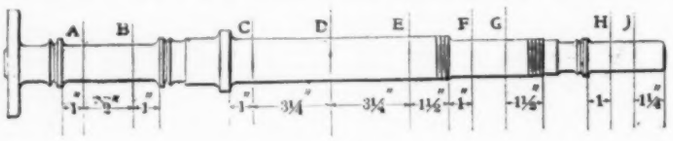
ALLOWANCES—BELOW STANDARD—FOR PUSH OR KEYING FITS, CLASS P GAGES.

Class of Gage,	Diameters,	½″	1″	2″	3″	4″	5″	6″
X.	Mean	.00150	.00200	.00260	.00320	.00380	.00440	.00500
	High	.00100	.00125	.00175	.00200	.00250	.00300	.00350
	Low	.00200	.00275	.00350	.00425	.00500	.00575	.00650
	Margin	.00100	.00150	.00175	.00225	.00250	.00275	.00300
Y.	Mean	.00100	.00150	.00190	.00230	.00270	.00310	.00350
	High	.00075	.00100	.00125	.00150	.00200	.00225	.00250
	Low	.00125	.00200	.00250	.00300	.00350	.00400	.00450
	Margin	.00050	.00100	.00125	.00150	.00150	.00175	.00200
Z.	Mean	.000625	.00100	.00120	.00140	.00160	.00180	.00200
	High	.00050	.00075	.00075	.00100	.00100	.00125	.00125
	Low	.00075	.00125	.00150	.00200	.00225	.00250	.00275
	Margin	.00025	.00050	.00075	.00100	.00125	.00125	.00150

Class X is suitable for engine and other work where easy fits are wanted.
Class Y is suitable for high speeds and good average machine work.
Class Z is suitable for fine tool work.

CLEARANCES FOR RUNNING FITS.

TABLE 3. LIMITS AND ALLOWANCES IN WORK-SHOP GAGES FOR DIFFERENT KINDS OF FITS.



Diameters at	The second diameter at each point to be taken at right angles to the first.																	
	A		B		C		D		E		F		G		H		J	
No. 1	1.499	1.499	1.4995	1.4995	1.7515	1.7515	1.7515	1.7515	1.7515	1.7515	1.625	1.625	1.625	1.625	1.124	1.124	1.124	1.124
" 2	1.5005	1.5005	1.5005	1.5005	1.7515	1.7515	1.7515	1.7515	1.7515	1.7515	1.6245	1.6245	1.6245	1.6245	1.1235	1.1235	1.1235	1.1235
" 3	1.499	1.499	1.4995	1.4995	1.7515	1.7515	1.7515	1.7515	1.7515	1.7515	1.625	1.625	1.625	1.625	1.124	1.124	1.1235	1.1235
" 4	1.500	1.500	1.499	1.499	1.751	1.7505	1.7515	1.7505	1.7515	1.7505	1.625	1.6245	1.6245	1.6245	1.1235	1.1235	1.1235	1.1235
" 5	1.4975	1.4975	1.498	1.498	1.751	1.751	1.751	1.751	1.7515	1.7515	1.625	1.625	1.6245	1.6245	1.1235	1.1235	1.123	1.123
" 6	1.499	1.499	1.499	1.499	1.7515	1.7515	1.7515	1.7515	1.751	1.751	1.6245	1.6245	1.6235	1.6235	1.123	1.123	1.124	1.124
Greatest	1.5005				1.7515						1.625				1.124			
Least	1.4975				1.7505						1.6235				1.123			
Difference	.003				.0010						.0015				.001			

TABLE 2. ACTUAL VARIATION IN RUNNING AND KEYING FITS

this character the usual practice is reversed, the variation in diameter being in the hole, while the shaft is kept to standard size.

STANDARD REAMERS AND PLUG GAGES

The holes are made with standard reamers, which are maintained at the standard taper, and in each case are sunk into the work to a point determined by Table 6 and defined by an adjustable stop gage, which abuts against a machined face on the work. A plug gage shown in the illustration, Fig. 30, is ground to the Hunt taper and to the exact diameter at the zero point *A*. It is also graduated at intervals of 1/16 inch of its length as shown. A taper of 3/16 inch per foot is very closely 0.001 inch for each 1/16 inch of length, and each division on the scale thus represents very nearly 0.001 inch difference in diameter. One of these intervals is called a "P" and is so entered on the drawings.

MAKING THE FIT

All shafts for taper fits are turned to within plus or minus 0.001 inch of the nominal size at the large end of the taper.

FIG. 30. HUNT TAPER PLUG GAGE

The taper reamer is then sunk in the hole to such a depth that the hole at the large end is small by an amount indicated by the table. Thus for a two-inch press fit the plug gage must enter the hole to such a depth that its large end registers between the 6 *P* and the 7 *P* mark, indicating that the hole is between 0.006 and 0.007 small. The parts are then pressed together until the true sizes match—that is, in the case of the two-inch fit the parts would be pressed between 6/16 and 7/16 of an inch.

FITS WITH KEYS AND WITHOUT

In case the shafts and wheels thus fitted are not driving members, no key is used, the grip of the press fit being found to be all sufficient. In case they are driving members—for example, the driving shafts and wheels of the Hunt electric locomotive—the shaft is key-seated for one or more Woodruff keys, the keys being placed in position before the parts are pressed together and being entirely hidden when the work is done.

THE DRAWINGS AND THE LIMIT EXPERT

These allowances are entered upon the drawings in the manner shown in the article on the Hunt company's drawing office system at page 989, Vol. 26. They are not, however, entered by the draftsman, his duty being to enter the nominal size only, and to be particular that the figure is so placed as to leave room for the addition of the limit figures. The drawings all go from the draftsman to a limit expert, who adds the limit figures. The reason for this is that while in all ordinary cases the table may be safely followed, there are nevertheless cases in which it must be departed from. These cases require expert knowledge of conditions and of previous cases, and hence the

Diameters . . .		1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	Formula:
Press Fit . .	Shaft	+ .001	+ .002	+ .003	+ .004	+ .005	+ .006	+ .007	+ .008	+ .009	+ .010	+ (.001 d + .000)
		+ .002	+ .003	+ .004	+ .005	+ .006	+ .007	+ .008	+ .009	+ .010	+ .011	+ (.001 d + .001)
Drive Fit . .	Shaft	+ .0005	+ .001	+ .0015	+ .002	+ .0025	+ .003	+ .0035	+ .004	+ .0045	+ .005	+ (.0005 d + .000)
		+ .0015	+ .002	+ .0025	+ .003	+ .0035	+ .004	+ .0045	+ .005	+ .0055	+ .006	+ (.0005 d + .001)
Hand Fit . .	Shaft	— .001	— .001	— .001	— .002	— .002	— .002	— .003	— .003	— .003	— .003	. . . . .
		— .002	— .002	— .002	— .003	— .003	— .003	— .004	— .004	— .004	— .004	. . . . .
All Fits. .	Hole	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	. . . . .
		— .002	— .002	— .002	— .003	— .003	— .003	— .004	— .004	— .004	— .004	. . . . .

TABLE 4. LIMITS TO DIAMETERS OF PARALLEL SHAFTS AND BUSHINGS (SHAFTS CHANGING)

Diameters . . .		1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	Formula:
Close Fit. .	Shaft	— .003	— .004	— .005	— .006	— .007	— .008	— .009	— .010	— .011	— .012	— (.001 d + .002)
		— .005	— .006	— .007	— .008	— .009	— .010	— .011	— .012	— .013	— .014	— (.001 d + .004)
Free Fit. . .	Shaft	— .008	— .009	— .010	— .011	— .012	— .013	— .014	— .015	— .016	— .017	— (.001 d + .007)
		— .011	— .012	— .013	— .014	— .015	— .016	— .017	— .018	— .019	— .020	— (.001 d + .010)
Loose Fit. .	Shaft	— .023	— .026	— .029	— .032	— .035	— .038	— .041	— .044	— .047	— .050	— (.003 d + .020)
		— .028	— .031	— .034	— .037	— .040	— .043	— .044	— .049	— .052	— .055	— (.003 d + .025)
All Fits. . .	Hole	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	+ .000	. . . . .
		— .002	— .002	— .002	— .002	— .003	— .003	— .003	— .004	— .004	— .004	. . . . .

TABLE 5. LIMITS TO DIAMETERS OF PARALLEL JOURNALS AND BEARINGS (JOURNALS CHANGING)

Diameters . . .		1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	Formula:
Press Fit . .	Hole	— 5 P	— 6 P	— 7 P	— 8 P	— 9 P	— 10 P	— 11 P	— 12 P	— 13 P	— 14 P	— (P d + 4 P)
		— 6 P	— 7 P	— 8 P	— 9 P	— 10 P	— 11 P	— 12 P	— 13 P	— 14 P	— 15 P	— (P d + 5 P)
Drive Fit .	Hole	— ½ P	— 1 P	— 1½ P	— 2 P	— 2½ P	— 3 P	— 3½ P	— 4 P	— 4½ P	— 5 P	— (½ P d + 0)
		— 1 P	— 2 P	— 2½ P	— 3 P	— 3½ P	— 4 P	— 4½ P	— 5 P	— 5½ P	— 6 P	— (½ P d + P)
Hand Fit . .	Hole	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
		— 1 P	— 1 P	— 1 P	— 1 P	— 1 P	— 1 P	— 1 P	— 1 P	— 1 P	— 1 P	— P

TABLE 6. LIMITS TO DIAMETERS OF TAPER SHAFTS AND BUSHINGS (HOLES CHANGING)

THE C. W. HUNT LIMIT SYSTEM

matter is confided to the judgment of a single man.

In all cases the tables apply to steel shafts and cast-iron wheels or other members. In the right-hand columns of the tables the formulas from which the allowances are calculated are given, and from which the range of tables may be extended.

RUNNING-FIT LIMITS IN A GERMAN PLANT

A number of years ago, while starting up the manufacture of medium and heavy machine tools, it was decided to adopt a systematic set of limits for reamed holes and running fits. There is nothing specially new in that in this country, although it is by no means as general for medium and heavy machine building as it should be; but in Germany, where the new works were located, limit gages met with but slight appreciation outside of establishments engaged in the manufacture of small arms, sewing machines and similar articles. In larger works the general practice was to consider the journal diameter as fixed and to vary for the character

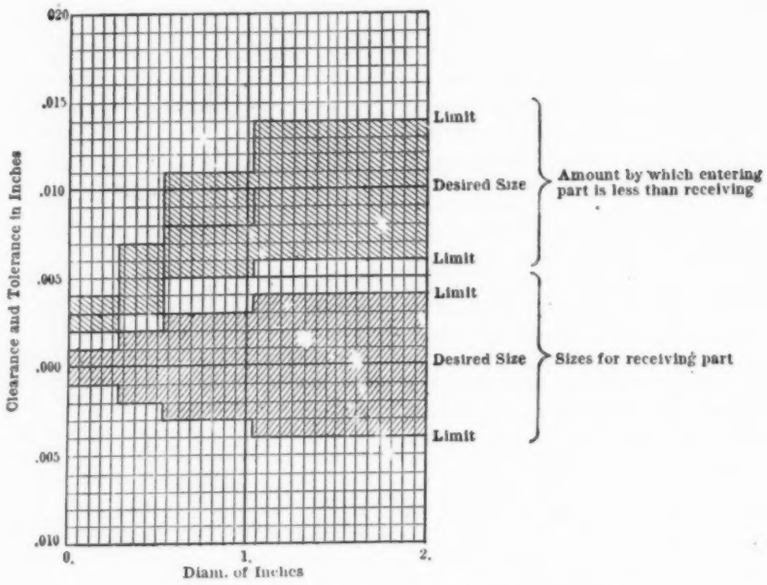


FIG. 32. SHOWING LIMIT SIZES GIVEN IN TABLE 7

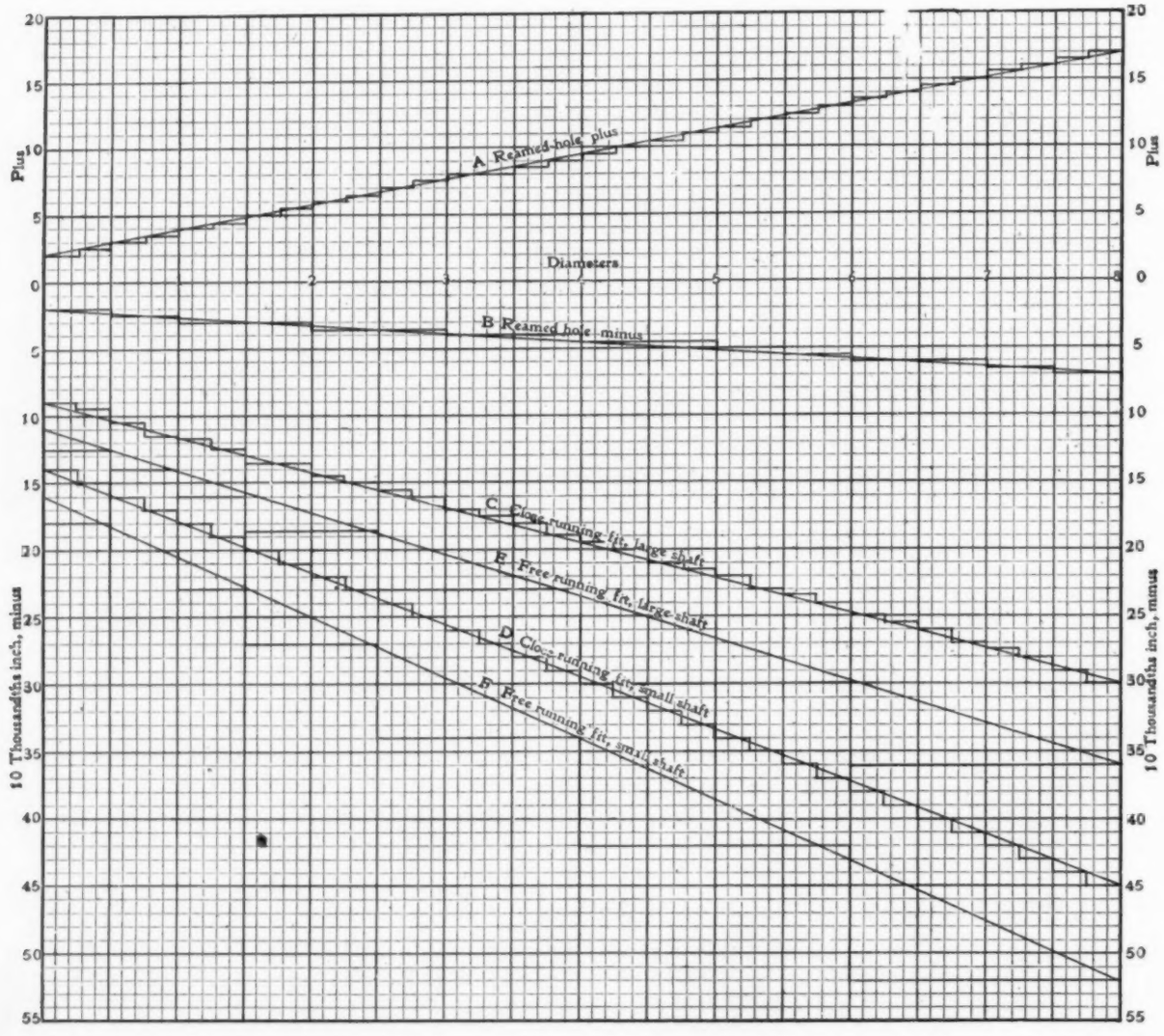

Plus
10 Thousandths inch, minus
Diameters
A Reamed hole plus
B Reamed hole minus
C Close running fit, large shaft
E Free running fit, large shaft
D Close running fit, small shaft
F Free running fit, small shaft

FIG. 31. GERMAN SHOP SYSTEM OF LIMIT SIZES FOR REAMED HOLES

Nominal Size.	Clearance.	Tolerance.	Receiving			Entering.		
			Maximum Limit.	Desired Size.	Minimum Limit.	Maximum Limit.	Desired Size.	Minimum Limit.
1 16	.003	.001	.064	.063	.062	.061	.060	.059
1-8	.003	.001	.126	.125	.124	.123	.122	.121
3-16	.003	.001	.189	.188	.187	.186	.185	.184
1-4	.003	.001	.251	.250	.249	.248	.247	.246
5-16	.005	.002	.315	.313	.311	.310	.308	.306
3-8	.005	.002	.377	.375	.373	.372	.370	.368
7-16	.005	.002	.440	.438	.436	.435	.433	.431
1-2	.005	.002	.502	.500	.498	.497	.495	.493
9-16	.008	.003	.566	.563	.560	.558	.555	.552
5-8	.008	.003	.628	.625	.622	.620	.617	.614
11-16	.008	.003	.691	.688	.685	.683	.680	.677
3-4	.008	.003	.753	.750	.747	.745	.742	.739
13-16	.008	.003	.816	.813	.810	.808	.805	.802
7-8	.008	.003	.878	.875	.872	.870	.867	.864
15-16	.008	.003	.941	.938	.935	.933	.930	.927
1	.008	.003	1.003	1.000	.997	.995	.992	.989
1 1-16	.010	.004	1.067	1.063	1.059	1.057	1.053	1.049
1 1-8	.010	.004	1.129	1.125	1.121	1.119	1.115	1.111
1 3-16	.010	.004	1.192	1.188	1.184	1.182	1.178	1.174
1 1-4	.010	.004	1.254	1.250	1.246	1.244	1.240	1.236
1 5-16	.010	.004	1.317	1.313	1.309	1.307	1.303	1.299
1 3-8	.010	.004	1.379	1.375	1.371	1.369	1.365	1.361
1 7-16	.010	.004	1.442	1.438	1.434	1.432	1.428	1.424
1 1-2	.010	.004	1.504	1.500	1.496	1.494	1.490	1.486
1 9-16	.010	.004	1.567	1.563	1.559	1.557	1.553	1.549
1 5 8	.010	.004	1.629	1.625	1.621	1.619	1.615	1.611
1 11-16	.010	.004	1.692	1.688	1.684	1.682	1.678	1.674
1 3-4	.010	.004	1.754	1.750	1.746	1.744	1.740	1.736
1 13-16	.010	.004	1.817	1.813	1.809	1.807	1.803	1.799
1 7-8	.010	.004	1.879	1.875	1.871	1.869	1.865	1.861
1 15-16	.010	.004	1.942	1.938	1.934	1.932	1.928	1.924
2	.010	.004	2.004	2.000	1.996	1.994	1.990	1.986

TABLE 7. LIMIT SIZES FOR GENERAL WORK

of the fit in the hole, contrary to our general way of working.

VARIATION IN BORED OR REAMED HOLES

In the standards adopted, the bored or reamed holes were allowed to vary most from the nominal diameter on the plus side. The variation permitted the maker of the reamer was about one-third that between the upper hole limit and the nominal size.

In the diagram, Fig. 31, these limits are shown for all sizes up to eight inches diameter; the horizontal line marked *O* is marked also with the various diameters; the upper stepped line *A* gives the largest diameter permitted, and *B*, the one next below, the smaller bore limits; the vertical distance between the two stepped lines measures the total variation permitted.

The limits are all given in ten-thousandths of an inch on the vertical scales at the right and left sides.

CLOSE-RUNNING AND FREE-RUNNING FITS

At first only one character of running fit was allowed with limits as given by lines *C* and *D*, and marked "close-running fit." Experience soon demonstrated that for all journals, except a few requiring very accurate fitting, such as main spindles, these fits were closer than really was necessary, and were moreover likely to cause trouble from seizing unless very carefully oiled and kept clear of gummed oil; that being the case and a larger limit also having the advantage of cheaper production, limits for "free-running fits" were adopted as given by the lines marked *E* and *F*.

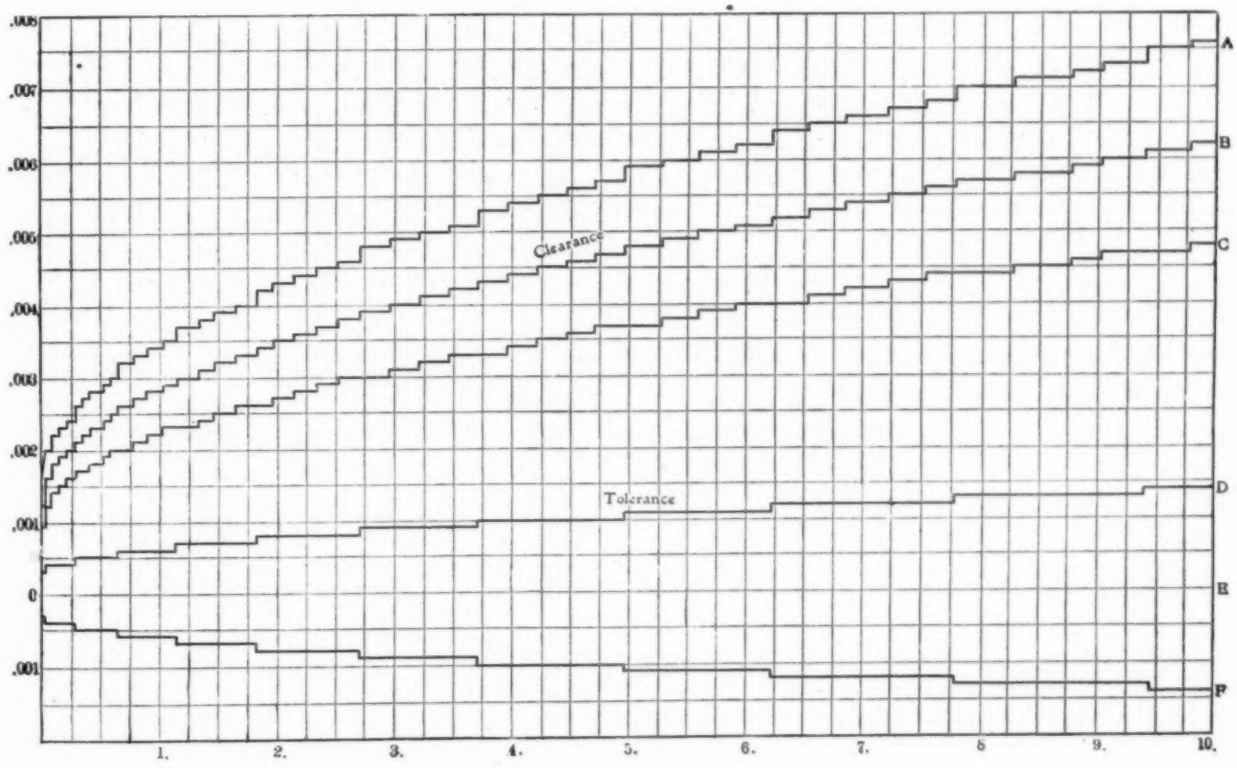


FIG. 33. SHOWING LIMIT SIZES GIVEN IN TABLE 8

APPLICATION OF THE DIAGRAM

In illustration, take the one-inch sizes from the diagram: The nominal one-inch hole is allowed a total variation of seven points—each point being 0.0001 of an inch—of which variation four points are plus and three minus. The reamer when new was permitted a reduction of two points from the larger limit; that gave a range of reamer wear of from five to seven points. The close-running fit is from 11 to 17 points smaller than the nominal inch size. The least difference between shaft or journal and bore is eight points as read off between the stepped lines *B* and *C*, and the greatest 21 points between lines *A* and *D*. A free-running fit is smaller than its nominal one inch by from 14 to 20 points, a variation of six points; the difference between journal and bore diameters—lines *B* and *E* and *A* and *F*—ranges from 11 to 24 points

Several years' experience with these limits showed them to be well adapted to the class of machinery built. While those used were actually in the metric system of measurement the diagram gives the equivalents in inches very closely.

ANOTHER AMERICAN SYSTEM OF RUNNING-FIT LIMITS

The tables and chart referred to below and reproduced herewith should be of considerable interest to draftsmen and others.

Table 7 is recommended for use in the ordinary shop and is suitable for parts of harvesting machinery, bolts, nuts across flats, wrenches and all places where loose fits are not objectionable. The chart in Fig. 32 is a graphical representation of this table. It is thought that Table 7 will generally give good enough fits and keep the cost of manufacture within reasonable limits.

ALLOWANCES FOR FINE WORK

Table 8 is for fine work and advances by ten-thousandths of an inch. Where nice fits are required this table may be used; but it must be remembered that the cost advances rapidly as one holds the machinist down to close measurements. This table gives considerably more freedom than that recommended in the preceding section on German practice. Fig. 33 is a graphical representation of Table 8.

DERIVATION OF THE SIZES

The sizes given in these tables for entering parts are the sizes of the test tools as measured with a micrometer caliper or measuring machine. The tool must enter (or not enter) freely in the work, without force. The sizes given for receiving parts are the sizes of entering parts which fit "nicely" in the receiving gages.

The first part of the art of calipering is in making our caliper points in a suitable manner for measuring with accuracy; and when we have learned that, we are better able to acquire the art of using them.

PRESSURES AND ALLOWANCES FOR FORCE FITS

Some Valuable Data from Various Engineering Establishments

Reference has already been made in this supplement to the practice of the Lane & Bodley Company of Cincinnati, O., in the matter of force fits. For several years this firm has been keeping a record of observations on press fits with a view to making an analysis of them when a sufficient body of data had accumulated, and thus obtaining a guide for future practice. Hundreds of cases of such press fits have been recorded, forming a body of data which is probably unequaled. These data have been plotted, compared and analyzed by T. C. Kelly, who has had charge of the record, and his conclusions are embodied in the diagram, Fig. 34.

MEASUREMENTS AND PRESSURE READINGS

In these records the measurements have been made with great thoroughness. Both plug and hole have been measured on two diameters and at both ends, the average of these micrometer readings being taken as the true diameter. The pressures have been read at the beginning, middle and

Size Marked on Drawing for both Entering and Receiving Parts	Clearance	Tolerance	Receiving			Entering		
			Maximum Limit	Desired Size	Minimum Limit	Maximum Limit	Desired Size	Minimum Limit
.0000	.0012	.0003						
.0625	.0016	.0004	.0629	.0625	.0621	.0613	.0609	.0605
.125	.0018	.0004	.1254	.125	.1246	.1236	.1232	.1228
.1875	.0019	.0004	.1879	.1875	.1871	1860	.1856	.1852
.25	.0020	.0004	.2504	.25	.2496	.2484	.2480	.2476
.3125	.0021	.0005	.3130	.3125	.3120	.3109	.3104	.3099
.375	.0022	.0005	.3755	.375	.3745	.3733	.3728	.3723
.4375	.0023	.0005	.4380	.4375	.4370	.4357	.4352	.4347
.5	.0023	.0005	.5005	.5	.4995	.4982	.4977	.4972
.5625	.0024	.0005	.5630	.5625	.5620	.5606	.5601	.5596
.625	.0025	.0005	.6255	.625	.6245	.6230	.6225	.6220
.6875	.0026	.0006	.6881	.6875	.6869	.6855	.6849	.6843
.75	.0026	.0006	.7506	.75	.7494	.7480	.7474	.7468
.8125	.0027	.0006	.8131	.8125	.8119	.8104	.8098	.8092
.875	.0027	.0006	.8756	.875	.8744	.8729	.8723	.8717
.9375	.0028	.0006	.9381	.9375	.9369	.9353	.9347	.9341
1.	.0028	.0006	1.0006	1.	.9994	.9978	.9972	.9966
1.0625	.0029	.0006	1.0631	1.0625	1.0619	1.0602	1.0596	1.0590
1.125	.0029	.0006	1.1256	1.125	1.1244	1.1227	1.1221	1.1215
1.1875	.0030	.0007	1.1882	1.1875	1.1868	1.1852	1.1845	1.1838
1.25	.0030	.0007	1.2507	1.25	1.2493	1.2477	1.2470	1.2463
1.3125	.0030	.0007	1.3132	1.3125	1.3118	1.3102	1.3095	1.3088
1.375	.0031	.0007	1.3757	1.375	1.3743	1.3726	1.3719	1.3712
1.4375	.0031	.0007	1.4382	1.4375	1.4368	1.4351	1.4344	1.4337
1.5	.0032	.0007	1.5007	1.5	1.4993	1.4975	1.4968	1.4961
1.5625	.0032	.0007	1.5632	1.5625	1.5618	1.5600	1.5593	1.5586
1.625	.0032	.0007	1.6257	1.625	1.6243	1.6225	1.6218	1.6211
1.6875	.0033	.0007	1.6882	1.6875	1.6868	1.6849	1.6842	1.6835
1.75	.0033	.0007	1.7507	1.75	1.7493	1.7474	1.7467	1.7460
1.8125	.0033	.0007	1.8132	1.8125	1.8118	1.8099	1.8092	1.8085
1.875	.0034	.0008	1.8758	1.875	1.8742	1.8724	1.8716	1.8708
1.9375	.0034	.0008	1.9383	1.9375	1.9367	1.9349	1.9341	1.9333
2.	.0035	.0008	2.0008	2.	1.9992	1.9973	1.9965	1.9957
2.0625	.0035	.0008	2.0633	2.0625	2.0617	2.0598	2.0590	2.0582
2.125	.0035	.0008	2.1258	2.125	2.1242	2.1223	2.1215	2.1207
2.1875	.0036	.0008	2.1883	2.1875	2.1867	2.1847	2.1839	2.1831
2.25	.0036	.0008	2.2508	2.25	2.2492	2.2472	2.2464	2.2456
2.3125	.0036	.0008	2.3133	2.3125	2.3117	2.2097	2.3089	2.3081
2.375	.0037	.0008	2.3758	2.375	2.3742	2.3721	2.3713	2.3705
2.4375	.0037	.0008	2.4383	2.4375	2.4367	2.4346	2.4338	2.4330
2.5	.0037	.0008	2.5008	2.5	2.4992	2.4971	2.4963	2.4955
2.5625	.0038	.0008	2.5633	2.5625	2.5617	2.5595	2.5587	2.5579
2.625	.0038	.0008	2.6258	2.625	2.6242	2.6220	2.6212	2.6204
2.6875	.0038	.0008	2.6883	2.6875	2.6867	2.6845	2.6837	2.6829
2.75	.0039	.0009	2.7509	2.75	2.7491	2.7470	2.7461	2.7452
2.8125	.0039	.0009	2.8131	2.8125	2.8116	2.8095	2.8086	2.8077
2.875	.0039	.0009	2.8759	2.875	2.8741	2.8720	2.8711	2.8702
2.9375	.0039	.0009	2.9384	2.9375	2.9366	2.9345	2.9336	2.9327

TABLE 8. LIMIT SIZES FOR ACCURATE INTERCHANGEABLE PARTS

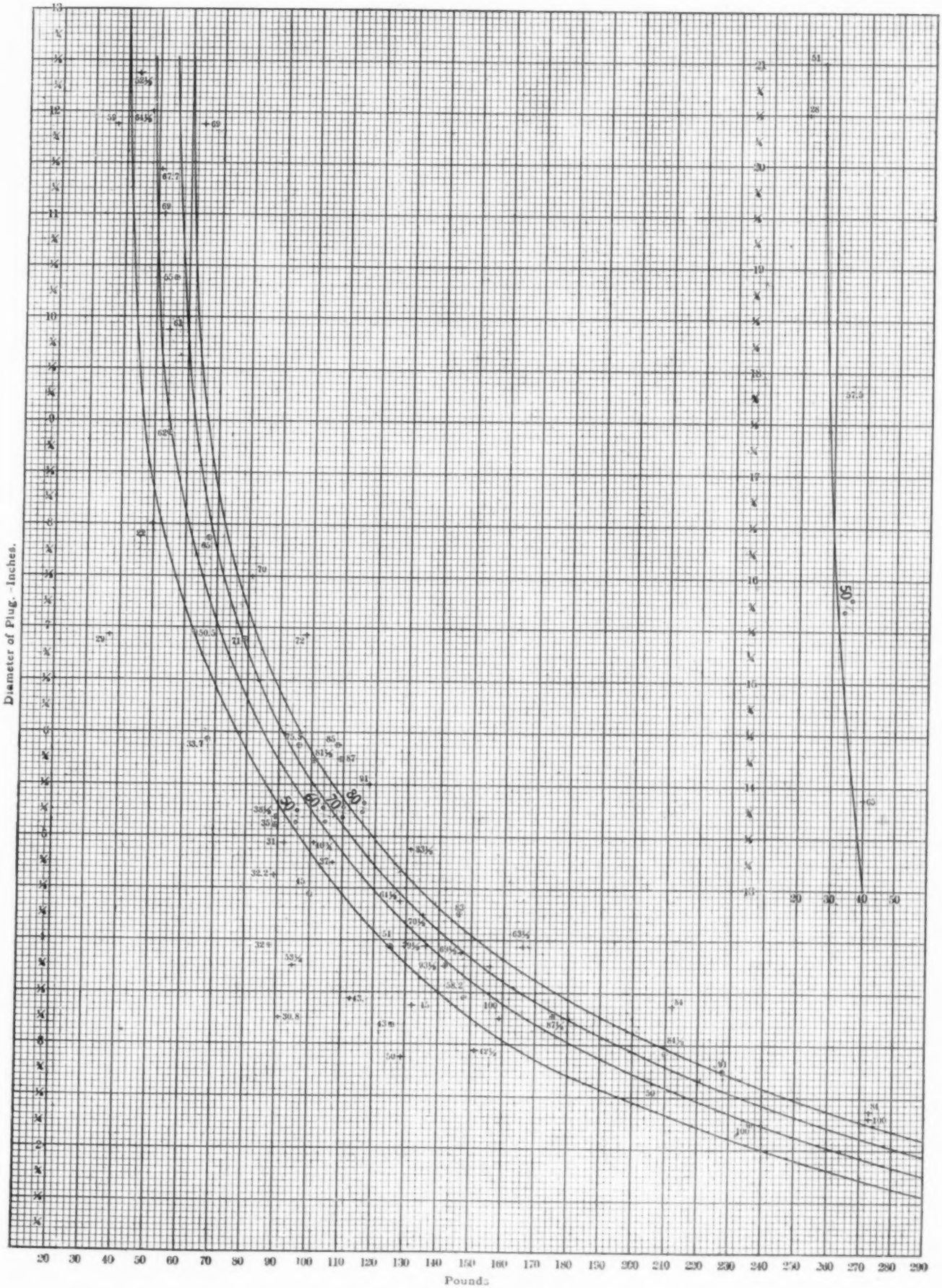


FIG. 34. FORCE-FIT DIAGRAM, SHOWING LANE & BODLEY PRACTICE

end of the length of the fit; the material of both plug and ring, the length of the fit, the radial thickness of the hub, the areas and volumes of the fitted surfaces, and some other minor points have been noted, 24 entries being regularly made for each case. The resulting diagram will thus be seen to have a very broad foundation.

In ordinary cases the quantities which are fixed by the conditions are the nominal diameter and length of the fit, the radial thickness of the hub, and the material. With these given it is required to find the press allowance for a given pressure to force the plug home.

HOW THE PRESSURE VARIES

Regarding the influence of these various factors, Mr. Kelly's conclusions are that the pressure varies:

1. Directly as the surface of the fit for a given diameter.

2. Directly as the press-fit allowance, this allowance being such as not to stretch the metal beyond the elastic limit.

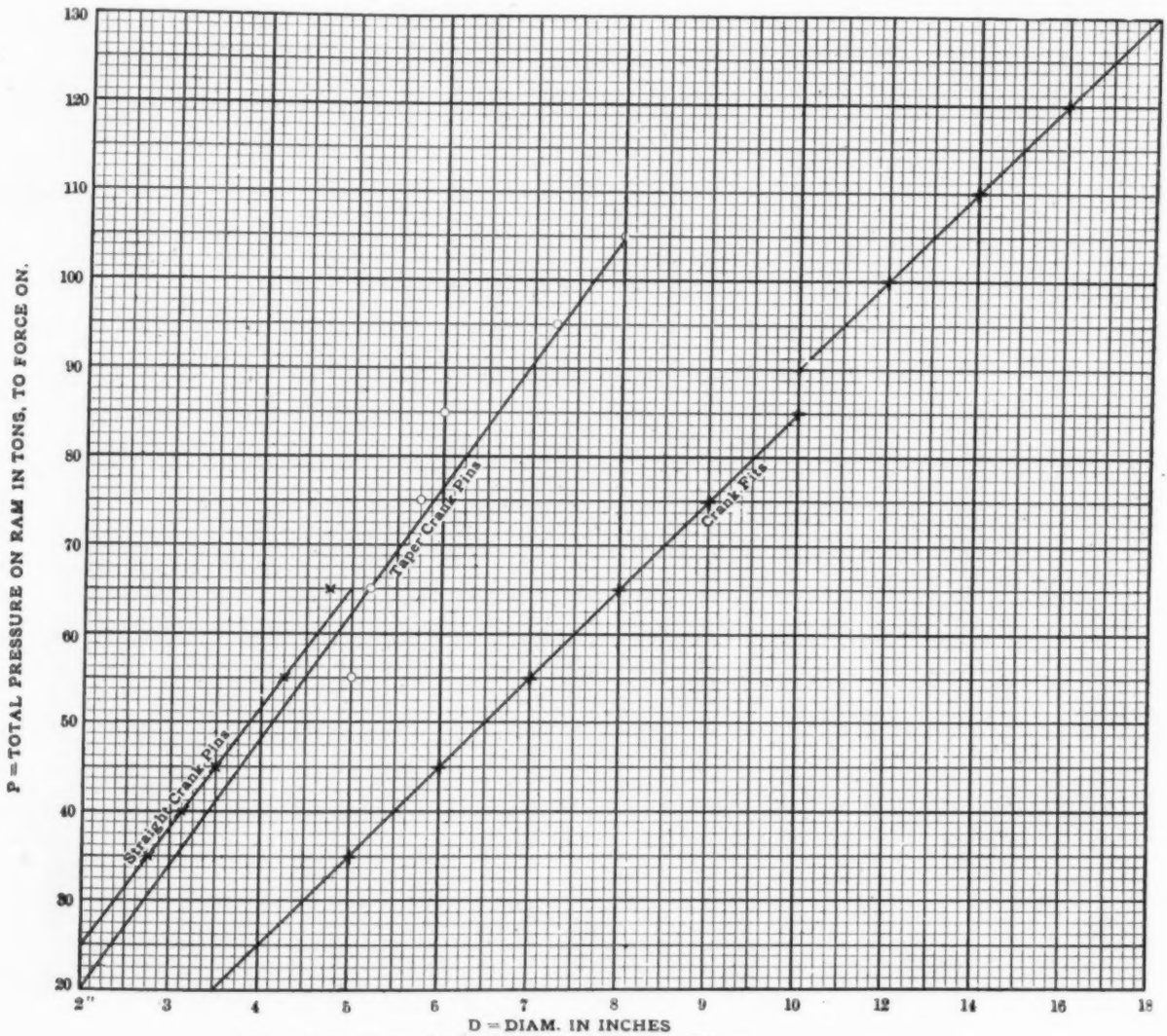
3. As some function of the radial thickness of the hub, which, while not determined mathematically, is shown in the diagram.

4. With the materials used in a manner not yet determined owing to insufficient data. The diagram is for steel or iron shafts and cast-iron cranks. Cast-steel cranks require much heavier pressures for the same press-fit allowances, but how much heavier cannot at present be said.

5. With other conditions which cannot be formulated, and which lead to erratic results in the observations and make it impossible to formulate a rule or construct a diagram which shall give other than approximate results.

VARYING CONDITIONS

Among these are the nature of the surfaces as regards smoothness, the varying character of materials going under the same name, the shape of the crank and the speed with which the work is done. The term cast iron includes materials of widely varying hardness and other properties, and it is apparent that the web of a disk crank would have an influence not expressed by the radius of the hub. If a counterbalance were cast in the disk, this and the crank arm would naturally produce an effect on the effective thickness of the hub which would be different from the effect of the arm alone on a plain



Approximate Formulæ Deduced from Plotted Points.

Crank fits $P = 9.9D - 14$ up to $D = 10''$.
Crank fits $P = 5D + 40$ from $D = 12''$ to $24''$.
Straight crank pins $P = 13D$.
Taper crank pins $P = 14D - 7$.

For cranks and straight pins allow .0025" per inch of diameter. Taper crank pins are fitted on the lathe to within ⅛" of shoulder and then forced home. Taper 1-16" per inch.

FIG. 35. PRESS FITS IN ANOTHER ENGINE SHOP

crank. Again, with a plain crank, the arm, being taper, would reinforce a greater arc of the pin eye than of the shaft eye.

STILL ANOTHER FACTOR

Another factor, which no doubt introduces some of the discrepancies of the diagram, is that while most of the shafts were of steel, some were of wrought iron, and no discrimination between these materials has been made in the analysis. These considerations explain the erratic results obtained but it is nevertheless plain that the observations follow the general direction of the curves in a very marked manner.

AVERAGES SHOWN BY THE DIAGRAM

The plotted observations, it should be remarked, are in most cases the averages of many. The figures attached give the percentage of radial hub thickness to plug diameter. It will be observed in this connection that the discrepancies grow less as the diameters increase. This is doubtless chiefly due to the fact that the percentage of error is always greater with small experiments than with large. Its effect is to give increased value to the diagram when used with large sizes where it is most needed.

THE PROBLEM SOLVED BY THE CURVES

Of course, the holding power of these fits is the real thing desired, but it is obvious that the probability of adequate experiments being undertaken to determine this in large sizes is slight. The problem as it presents itself in the shop calls for the determination of the press-fit allowance to give a required pressure in forcing the parts home, and this the present diagram solves with a degree of accuracy sufficient for most purposes.

In order to reduce the size of the diagram, the portion applying to diameters above 13 inches has been detached and placed at the right. For these large sizes the observations are too few to justify the drawing of more than one curve. The lubricant used in all cases was linseed oil.

AN EXAMPLE

The following example illustrates the use of the diagram: Diameter of plug 8 inches, length of fit 6 inches, diameter of hub 16 inches, press-fit allowance 0.020 inch. Required, the pressure to force the parts together.

$$\frac{\textit{Radial thickness of hub} = 4 \textit{ inches}}{\textit{Diameter of plug} = 8 \textit{ inches}} = 0.5.$$

Finding a point on the 50 per cent. curve opposite 8 inches, and tracing downward, we find 52 pounds. Area of fitted surface $= 8 \times 3.1416 \times 6 = 150$ square inches, $52 \times 150 \times 20 = 156{,}000$ pounds $= 78$ tons.

DIRECTIONS FOR USE

Select the curve which gives the ratio of the radial thickness of the hub divided by the diameter of the plug. Below the point of intersection of the plug diameter line with the selected curve, read pounds. Multiply this reading by the area of the fitted surface in square inches, and by the number of thousandths of an inch allowed for the press fit. The result will be the pressure in pounds carried to force the plug home.

STRAIGHT AND TAPER FORCE FITS IN ANOTHER SHOP

While going through the shops of another prominent Ohio engine-building concern, a visitor noticed some cranks being forced on under hydraulic pressure. Seeing his manifest interest, they very courteously placed at his disposal a statement of their practice; this is plotted in the diagram, Fig. 35. *X* denotes their practice for straight crank pins; *O* denotes their practice for taper crank pins; + denotes their practice for crank fits.

EFFECT OF A SMALL DIFFERENCE IN THE FIT

With nearly all of these the various points fall on straight lines. The chief deviation, as was to be expected, is with the taper pins, where a very small difference in fitting amounts to a considerable variation of the forcing allowance. Note the break in the crank-fit line due to a change above 10 inches. The formula changes not only in the adding constant, but also in the multiplier. At first sight this is not apparent, as the direction of the line does not change; but this is only apparently so, as, in order to reduce the size of the diagram, the diameter scale is changed above 10 inches.

VARIATION IN FORCE REQUIRED

Naturally the force stated as required is not exact; the foreman superintending the operation says that it will vary 5 or 10 tons either way of the amounts given. Of course, the force stated is the maximum used just as the parts get home.

The difference between the forces necessary to press home shafts and crank pins of the same size is apparently due to the difference in length.

A CONTRIBUTION FROM ENGLAND ON FORCE FITS

An English contributor writing on the subject of force fits states that the line in the diagram, Fig. 35, giving crank fits, agrees very closely with the English practice with which he is acquainted, in which the disks are cast iron and the holes not polished, but left as smooth as a broad tool can make them. The pins, on the other hand, are put in at approximately the same pressure per inch of diameter (a minimum of six tons being the rule), but the allowance given to the pins has to be reduced to meet it. He ascribes this principally to the fact that the shaft and the shaft hole are key-wayed, while the pin-hole is not; and states that so far as his experience goes no hard-and-fast rule for the proper amount of allowance can be laid down, this depending largely on (1) finish of hole, whether polished or not; (2) quality of metal, whether hard or soft; and (3) design of disk, whether heavily bossed or well ribbed.

EFFECT OF INCREASED LENGTH

The length of the pin or shaft, he claims, has not much appreciable effect on the pressure required to force it home; but we may say that the testimony of the Lane & Bodley observations is positive that there is such an effect. We have seen the original records of these observations, during which readings were taken at the beginning, middle and end of the length, and the pressure at the end is quite uniformly double that at the middle, and this, we think, would naturally be expected.

VARIATIONS IN PRACTICE

Table 9 accompanying our English correspondent's letter shows variations met with in everyday practice. The writer adds that on one occasion two 4¾-inch pins were pressed in with 0.011 allowance, and both went in at 22 tons. This was considered too low, and the disks

PINS			SHAFTS			REMARKS
Diameter	Allowance	Press. in Tons	Diameter	Allowance	Press. in Tons	
3 in.	.006	18				
3⅛ in.	.0085	25				
3¾ in.	.0087	26				
4 in.	.0090	25				
4¾ in.	.0110	30				
5 in.	.0105	30	5 in.	.015	28	Disks identical.
			5 in.	.015	40	
			5 in.	.017	28	Disks identical, but of different design to above
			5 in	.017	33	
			5 in	.016	40	Hole not polished. Disks identical.
			5 in.	.018	40	Hole polished.
5¼ in.	.0115	35				
			5½ in	.014	30	Considered too low, but could not press off at 50 tons.
			5½ in.	.015	32	
5¾ in.	.0125	35				
			6 in	.014	50	
			6⅛ in.	.014	28	Disks identical.
			6½ in.	.014	35	
			6⅝ in.	.013	30	Could not press off at 50 tons.
			7¾ in.	.012	50	Disks identical.
			7¾ in.	.013	38	
			8¼ in.	.011	70	
			8¼ in.	.015	36	Could not press off at 60 tons.
			9⅛ in.	.011	55	Disks identical.
			9⅜ in.	.011	70	

TABLE 9. ENGLISH PRACTICE WITH FORCE FITS

were laid aside a couple of days until new pins could be turned. When it was then attempted to press out the old pins, neither would move at 70 tons.

DISCUSSION OF "FITS AND FITTING" AT AN A. S. M. E. CONVENTION

At the Saratoga meeting, June, 1903, of the American Society of Mechanical Engineers, a paper was presented by Stanley H. Moore, on "Fits and Fitting," the substance of which paper we gave in our report of that meeting. Some discussion of it, presented by John Riddell, of the General Electric Company's works, at Schenectady, will prove interesting. It is as follows:

MR. RIDDELL'S DISCUSSION

I have read the paper by Mr. Moore with a great deal of interest, and am very glad to see that some effort is being made to get the matter of allowances put in some tabulated form for future reference. I am particularly interested in this subject at this time, as I have prepared a diagram [Fig. 36] for our own use, and was just about to issue it.

A DIFFICULT TASK

In making up such tables and diagrams, it will be found a very difficult undertaking to make them suit all conditions, as I will try to point out. Before making any change in our present allowances I wrote to a number of engine builders for their opinion regarding the change, and received answers from about forty of them. The answers furnished very interesting reading matter. Some suggested that the present allowance was all right, others said the proposed allowance would be about right, while still others said it was not enough.

REASONS FOR CHANGING ALLOWANCES

My reasons for changing were: First, to have a gradually increasing allowance, and not in steps by 3 or 4 inches, because I contend that if an allowance is right for 10 inches the same allowance would not be right for 14 or 15 inches; second, our old allowance is 50 per cent. smaller than the proposed allowance, and gave no leeway to the shaft turner.

IMPORTANT CONSIDERATIONS

There are many things to be taken into consideration in laying out these tables and diagrams: First, the relation of length of bore to diameter should be considered. In our case the length of hubs of armature spiders is sometimes several times the diameter; but the actual bearing surface is about equal in length to the diameter, on account of recesses in the hub. Second, the outside diameter of hub should be taken into consideration. My diagram is laid out on the basis of the hub being twice the diameter of the shaft. Third, the nature of the materials should be considered; and fourth, how and where the parts are to be assembled; if they are to be assembled where a suitable hydrostatic press is available, more allowance can be made than if the parts are to be put together by the use of bolts and straps.

A DIAGRAM FOUNDED ON EXPERIENCE

My diagram is based on actual experience extending over a number of years, and the one we have at present in use is eminently satisfactory. In laying out the diagram we took the largest bore we had made and different smaller ones down to 2 or 3 inches, and plotted the curve to suit.

In my diagram I differ very widely from Mr. Moore in all of his tables, and also in some of his general deductions. By comparing some of his tables with our own experience, we have:

FORCING FIT

	Moore	Riddell
6 inches	0.0125	0.00125
12 inches	0.0245	0.00425
24 inches	0.0485	0.00450
30 inches	0.0605	0.00550
37 inches	.....	0.00650

SHRINK FIT

	Moore	Riddell
6 inches	0.0069	0.00350
12 inches	0.0133	0.00570
24 inches	0.0260	0.00925
30 inches	0.0324	0.01100
38 inches	.....	0.01325
12 feet	.....	0.04000

It will be noticed by the above that Mr. Moore allows about ten times more for pressure fits than in my proposed table. It will also be noticed that Mr. Moore allows less for shrinkage than for pressing, while my table gives double the amount.

EXPLANATION OF DIAGRAM

One of the reasons for making my table was to have something for the guidance of our designers and draftsmen. There are five curves shown as follows: The left-hand one on the minus side of o line shows allowances for sliding fit. I mean by this such fits as are not loose or free like a running fit, but one that will just slide without any perceptible play. The next curve is on the right or plus side of the o line and shows exactly the same allowances for tight fits for parts with light hubs, such as commutator shells, etc. The third curve gives somewhat greater allowances, and is used for steel hubs. The fourth is for our regular armature spiders of solid cast-iron hubs. The fifth shows the amount we have found to be correct for shrinkage fits, and for such heavy articles as couplings. Our bearings, or running fits, are not given, as it was not thought advisable to put too much on one sheet.

EDITORIAL COMMENT

At page 1138, Vol. 26, we published an editorial on "Allowance for Press Fits" in which we referred to the difference in practice as brought out in Mr. Riddell's discussion, as follows:

It is especially interesting to observe that in some cases allowances are made that are ten times what would be followed in another shop for precisely the same fit, that is, a fit of the same size and made for the same purpose. The net result of this will be, we think, to impress upon a great many the actual truth of the matter, that all such rules are themselves to be taken with considerable allowance.

THE PERSONAL EQUATION

It is a fact quite familiar to shop men, that different lathesmen making press fits get widely varying results when making the same allowance on the same work, or that two men will get the same result; their work will go together with practically the same pressure, though one man may aim to make, and may think he is making, an allowance considerably greater than that made by the other.

THE EFFECT OF COARSE FEEDS

There are several reasons for this. If the shaft is turned with a coarse feed and a tool somewhat rounding on the cutting edge, the result is a spiral ridge running around the shaft like a screw thread; and when such a shaft is pressed into a smoothly bored or reamed hole, the top of this thread needs only to be crushed down, and the intervening spaces afford plenty of space for the metal to flow into easily. The result is quite different from that in which the shaft is turned smooth, so that its entire surface will bear, though the two shafts may caliper alike. This effect is still more marked where both shaft and bore are rough.

ANOTHER SOURCE OF DISAGREEMENT

But what is perhaps a more fruitful cause of disagreement between different shops in this matter is the fact that there are so many workmen and shop inspectors who have no conception of the fact that some delicacy of touch is required in order to do accurate calipering or gaging. If a caliper or gage just barely touches the work as it goes over—if it just contacts so that, by paying close attention, the contact can be just felt and no more—then there is some assurance that the thing gaged or calipered is the size of the gage or of the caliper. But if the gage is pushed over by the employment of any appreciable force, then nothing whatever is known of the size of the work, either by the man who does the gaging or by anyone else.

THE NECESSITY FOR CAREFUL GAGING

If all calipers and gages possessed exactly the same rigidity, and if all work surfaces offered the same frictional resistance to the passing of a gage, and if all "jammers" who crowd gages over their work used precisely the same amount of force in doing it, then it might be possible to calibrate all these things and get uniform results. But none of these conditions is possible of attainment, and, as every experienced man who has given the matter an intelligent study knows full well, it is impossible to get results in cal-

ipering or gaging, which are at all comparable, in any other way than by having men to do the gaging who know how, and who know, among other things, that "jamming" a gage over work is not right and can never produce results that are at all reliable.

ONE WAY OF GAGING SHAFTS

We have known shops in which holes were produced by reamers or by means of gages that could not be forced, and were therefore standard, and in which at the same time shafts to fit these holes were gaged by snap gages "jammed" over by main force, and in which they thought they were making a very small allowance for fitting, whereas they were really making a large one; though nobody knew how large, because nobody knew just how much the gages were sprung in forcing them over the work.

AN IGNORANT INSPECTOR

Indeed tradition (not ancient tradition either) tells us of a large and important shop in which the inspector could not write down or intelligently handle a decimal fraction, and in which they supposed they were making a negative allowance in certain press fits, that is, making the shafts smaller than the holes. This they very ingeniously explained to themselves on the score of "imperfect holes, lack of roundness, lack of straightness," etc., etc., the fact being, as a few minutes' intelligent handling of a micrometer would have shown, that they were making a big allowance, all that the utmost powers of resistance of the snap gages used would allow, in the hands of a mechanically ignorant and brutal inspector.

THE LESSON FOR THE SHOP

The lesson of all this is that figures of allowances for press and other fits should not be taken too literally nor depended upon too implicitly. They may be based upon an intelligent and skilful use of gages, or they may possibly be based upon the same degree of abuse of them as happens to prevail in your own shop, in which case they will be all right for your use; but it is obviously not wise to count on these things "unless you know."

It may be very well to admire those giants among workmen who seem to know intuitively just how deep to set a tool to cut exactly the size wanted the first time trying; who know at the first time trying whether their calipers are set just right, and are never seen going back to feel a second or third time to see if their later judgment confirms their first opinion. Even if this sort of workmen were as accurate as their admirers would have us believe, they are not plenty enough so but that the men who feel, and feel, and still show some signs of misgivings as to the accuracy of their measurements till putting their work together "settles it," will still be called upon to do the bulk of the close work.

STANDARD MEASUREMENTS IN MACHINE CONSTRUCTION

Fine Work—Accurate Gages and Gage Making—Micrometers—Setting Calipers Closely to Size

In a lecture delivered by Fred J. Miller, before the Young Men's Institute of New York City, the speaker, after relating the history of the standards of length of the olden times and giving an account of the British standard yard and the French meter, described the Rogers-Bond comparator by which variations in size might be read to about $\frac{1}{40000}$ inch, and then explained as follows what that minute quantity really meant:

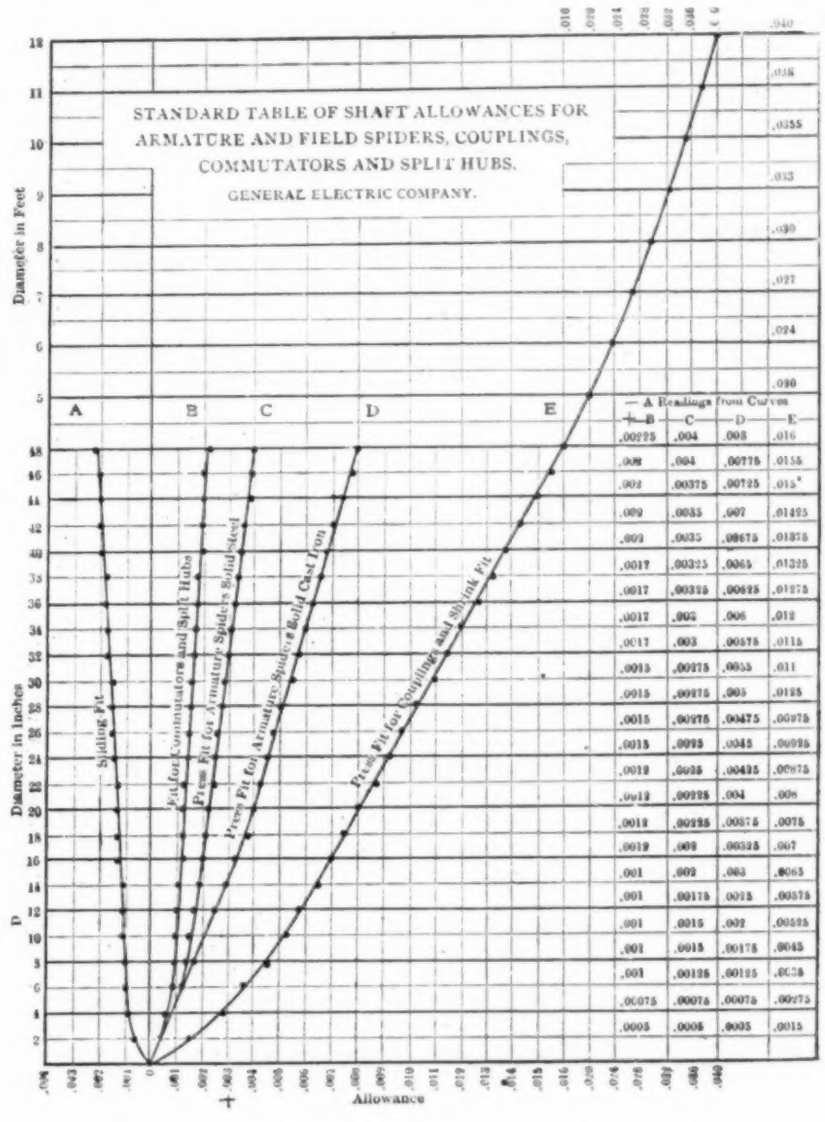

STANDARD TABLE OF SHAFT ALLOWANCES FOR ARMATURE AND FIELD SPIDERS, COUPLINGS, COMMUTATORS AND SPLIT HUBS.
GENERAL ELECTRIC COMPANY.
Diameter in Feet
Diameter in Inches
A
B
C
D
E
Sliding Fit
Fit for Commutators and Split Hubs
Press Fit for Armature Spiders Solid Steel
Press Fit for Armature Spiders Solid Cast Iron
Press Fit for Couplings and Shrink Fit
Allowance

FIG. 36. GENERAL ELECTRIC COMPANY'S DIAGRAM FOR PRESS FITS

"HAIR SPLITTING"

The expression "hair splitting" was formerly, and is now, sometimes used to designate people or mechanics who are supposed to be superfine, and who are not satisfied with working close enough, but must work finer, and in fact, unnecessarily fine. But today, in the finer grades of work, working no closer than to a hair would not do at all, and as a matter of fact a hair must be split and re-split many times before it becomes fine enough to be commensurate with the degree of accuracy attained. Some persons are much more "fine-haired" than others, but the hairs from my own head, which are probably about the average in fineness, are something more than 0.002 inch diameter.

A PLUG AND RING MADE TO FIT

Now I have here a plug and a ring gage made by the Brown & Sharpe Manufactur-

ing Company. They are hardened steel, ground and lapped very smooth and true, and, as you see, they fit each other very nicely. There is absolutely no play or looseness, yet when properly oiled and put together, the plug slides freely through the ring, as you see. Yet the fit is really very close—so close, in fact, that upon being allowed to rest for a moment they stick together, as you now see them, so that I am unable to separate them, even by the exertion of my full strength, and what appears to be violence must be used in forcing the ring off the plug; i.e., they must be hammered apart, and for that purpose, I use this block of wood having a hole bored through it, and a rawhide-faced hammer. This sticking is explained upon the supposition that, when motion stops, the minute particles of oil become flattened by the pressure, and thus no longer constitute what may be called a ball bearing, as they do while in a spherical state.

WHAT ONE-THOUSANDTH PLAY AMOUNTS TO

Now I have here another plug gage which is just 0.001 inch smaller in diameter; upon inserting it in the ring, it is seen to be quite loose, and the "shake," as we call it, is quite perceptible. Almost any machinist unaccustomed to micrometer measurements would say that it was pretty loose—1/64 inch, anyhow, and it is at once seen that any good machinist can work with ordinary spring or hinged calipers closer than 0.001 inch. Yet to go into the space between this plug and ring, an ordinary hair would literally have to be split, for the simple reason that its diameter is more than twice the size of the space between the plug and the ring.

This snap gage is just the size of the ring; any machinist would pronounce the job spoiled which was ground or turned as loose as that is; yet it is only 0.001 inch, or half a hair loose. But when we talk of $\frac{1}{2000}$ of an inch, than we mean a limit much below what is usual in machine work, and our hair would have to be split, not once, but 120 times, to equal it in fineness. . . .

REGARDING STANDARD GAGES

After describing the accuracy with which standard end-gages and others were made, and enlarging upon their importance in modern manufacturing operations, the lecturer continued as follows:

All that has been said heretofore, however, relates simply to the relation which the actual sizes of parts of machines and tools bear to certain recognized standard bars. It does not necessarily follow from this that closer or more accurate work can be done in ordinary machine-shop practice with standard gages than without them.

GOOD MEN WORK WITHIN SMALL LIMITS

A plug and ring can be fitted to each other as accurately, if it is done without any regard whatever to a standard size, as if the size is made to conform to a standard; for, as a matter of fact, machinists and toolmakers in ordinary good work, especially that which is made of hard steel ground or otherwise finished smooth and true, work within very small limits. I have shown you that a difference of diameter of 0.001 inch between a hard, round, smooth ring of steel and a plug of like finish and accuracy was easily perceptible; I will now show you that even a much smaller amount than this is easily perceived.

THE SNAP GAGE AND THE TEST PIECES

I have here one of the standard end-measure test pieces before referred to, made by the Pratt & Whitney Company, tested by their Rogers-Bond comparator and found to be precisely 1¼ inches in length. Here is a snap gage made by the same concern and of the same size. As will be seen, the end-measure piece fits the gage nicely and is sustained by the friction between the highly polished surfaces, this friction being sufficient to even sustain the heavier mass of the gage. Now this similar test piece is 0.0002 (or $\frac{1}{5000}$) of an inch shorter, and, as you see, is not sustained by the friction, but freely drops out. Here is another test piece which is only 0.0001 inch less in length than the first one, and, as you see, it also drops out of the gage, the contact not being sufficiently close to hold it. This means that a toolmaker who wished to make two such pieces of precisely the same length would certainly get them so within a limit of variation of less than 0.0001 part of an inch.

ACCURACY IN GAGE MAKING

I have here a ring gage 1¼ inches diameter. This plug is nominally of the same diameter, and, as you see, can be inserted by careful handling, provided always that the person handling it has had some previous practice with such gages. It sticks, as was seen to be the case with the other similar gage, and for the same reason. Now this plug is not 0.001 inch smaller, but 1/20 of this, or $\frac{1}{20000}$ of an inch smaller; you will readily perceive that it is not so close a fit as the other plug, which is about 1/40 the diameter of a hair larger, and upon applying the snap gage to the plug, a difference in diameter is readily detected. In other words, a good machinist or toolmaker aiming simply to make these plugs of the same size, without any regard to a standard of measurement, would surely lap the larger one down a little, and in so doing would make the two plugs vary from each other less than $\frac{1}{20000}$ of an inch.

WHAT IS ESSENTIAL IN THE DUPLICATION OF FINE WORK

Corresponding results are obtained when the diameters of the plugs are tested in this measuring machine, or bench-micrometer caliper, the larger plug being quite perceptibly tighter than the smaller one, and when the screw is moved to make them equally tight, as nearly as possible, the difference of the reading of the scale is by estimation just equal to their actual variation from each other. But the ability to distinguish the very small difference in diameter between two plugs, and to eliminate that difference, is an altogether different thing from being able to ascertain what that variation is in terms of an inch or other standard; and for doing this we must have a means of knowing just what an inch is, and it is highly important that an inch or any division of it shall mean the same thing when measured by the same workman at different times, or by different workmen in the same or even in widely separated shops.

STEEL SCALES ORIGINALLY DEPENDED UPON

In the early days machinists had nothing for this better than steel rules upon which lines are drawn representing inches and divisions of an inch. These scales themselves were and are surprisingly accurate, but the trouble was in getting accurate sizes from them.

If, for instance, a pulley or a gear wheel was to be bored out in one part of a shop, say for a two-inch shaft, and the shaft turned to fit it, it would not do to have the pulley bored in one part of the shop by one workman, and the shaft turned in another part of the shop by another workman, each setting his calipers to a scale or steel rule; for it would be morally certain that, when the two were brought together, they would not fit. Yet each workman could and probably, in such a case, would declare that he had bored that pulley, or that he had turned that shaft exactly two inches; and no one could dispute either of them, for, though it would of course be true that both could not be right, who should decide which was wrong?

SOME INTERESTING TESTS

I have made a test of this matter, using a small and delicate pair of inside calipers which I made and used for some years in the shop. As you see, they are of the common jointed type, but are small and light, weighing in fact less than ½ an ounce. It is, I think, a common mistake to make such calipers too large and heavy, and for nice work in transferring sizes from a micrometer caliper or other standard measuring device, it cannot be too much emphasized that such calipers should be light and delicate, in order that the slightest contact may be felt.

Placing a two-inch steel rule with one end against a block of steel, I rested one leg of the calipers against this block and adjusted the other to various sizes marked on the scale, using for the purpose a magnifying glass, and taking pains to set the calipers as accurately as possible. I set them to five different sizes, varying from each other by eighths of an inch, from ½ inch to one inch inclusive. After each setting I measured and determined the variation from correct size by means of

this one-inch micrometer caliper, and obtained the following results:

THE RESULTS OF THE TESTS

1 inch	0.99925 inch ..	— 0.00075 inch
⅞ inch	0.87650 inch ..	+ 0.00150 inch
¾ inch	0.77400 inch ..	— 0.00100 inch
⅝ inch	0.62450 inch ..	— 0.00050 inch
½ inch	0.50000 inch	.....

The figures in the first column give the nominal sizes measured, those in the second column the actual sizes that the micrometer showed the inside calipers to be set to, read by estimation to the nearest ten-thousandth of an inch; and the third column the variation from correct size, the signs preceding these figures indicating the direction of the error. It will be seen that the greatest error was 0.0015 inch, the smallest 0.0005 inch, and that there is between the ⅞-inch and the ¾-inch setting a total error of 0.0025 inch. Only one setting was just right. The smallest of these variations is sufficient to make the difference between a good fit and a poor one, as we have already seen, and it is to be noted that, in making the test, more pains were taken than would be taken in ordinary shop practice. . . .

ERRORS IN MICROMETER SCREWS

The speaker here stated the importance of having standard plugs and rings for reference and for setting calipers to, and then he took up the matter of micrometers; and in this connection Professor Sweet's scheme for overcoming the errors in their screws was discussed as follows:

It has not yet been found practicable to produce screws having exactly a predetermined pitch. All screws have at least some error, though in a few cases screws have been made that were very nearly exact. If exactly correct screws could easily be made, and then kept correct in use, the problem of exact standard measurements by micrometer gages would be much simplified; but since this cannot so far be done, the next thing is to devise a means of readily overcoming errors arising from inexact screws. To Professor Sweet is due the credit of overcoming this difficulty, which has been and is so important in connection with the use of micrometer calipers, that I have prepared a sketch (Fig. 37) which I hope will enable those of you who have never investigated the matter to readily understand it.

HOW THE ERROR IS OVERCOME

The sketch represents a plan view of the graduated disk, lineal scale, etc., of the bench caliper. The graduations on the disk *D* are read at the edge of the scale *S* and if the screw is exactly correct in pitch, i.e., so that just 10 revolutions advance it exactly one inch, then the edges of the scale are straight and parallel with the screw; but if there is an error in the screw then the scale is placed at such an angle as to compensate for the error. I have exaggerated the angularity in this case to make it more easily apparent, and it will be seen that, in advancing the screw just one inch, the graduated disk *D* would move along from the point *P* to the point *P'*; and supposing the contact points of the caliper to be just one inch apart when the scale reads zero at the outer end of scale, and to be together when it reads zero at the inner end, it is evident that the screw has made more than 10 revolutions by the amount of the angularity, the direction of the angularity in this case being that required for a screw too fine in pitch, or with slightly more than 10 threads per inch, instead of precisely 10 threads per inch.

This principle of arranging the reading line at such an angle as to cause the screw to be revolved slightly more or less than the nominal number of revolutions called for by its nominal pitch has been applied in a great many different forms, and has proven exceedingly useful.

THE READING OF VERNIERS

An Explanation of a Fine Measuring Instrument

It has been suggested to us that the use of verniers as applied to calipers is not as well understood as the merits of the instrument make desirable, and that an article explaining the reading of verniers would prove useful.

THE OBJECT OF THE VERNIER

The object of the vernier is to enable fine readings to be obtained from a scale having coarse divisions. As often made, the readings are ten times as small as the divisions of the scale, though verniers may be, and often are, made with other ratios. Using the ratio of ten, a vernier may be made to read to tenths of an inch from a scale which is divided into whole inches only. There would be no advantage in this, however, as it is perfectly easy to read a scale divided into tenths. Similarly a scale divided into tenths may be read to hundredths, and here the advantage of the arrangement begins to appear, as, while a scale divided into tenths may be read with perfect ease, one divided into hundredths requires some effort by the eye.

THE ADVANTAGE OF THE VERNIER

If the process be carried a step further, the advantage of the vernier is very apparent. A scale divided into thousandths could not be read without a glass, but by means of a vernier thousandths may be read from a coarser scale. This coarser scale may be divided into hundredths and the vernier may be made to divide these divisions by ten, but such an arrangement would not be very desirable, as a scale divided into hundredths is already pretty finely divided to read without a glass. As has already been said, the vernier may be made to divide the beam readings by any number and by using a larger division than ten the beam divisions are made coarser, as will be more fully explained further on.

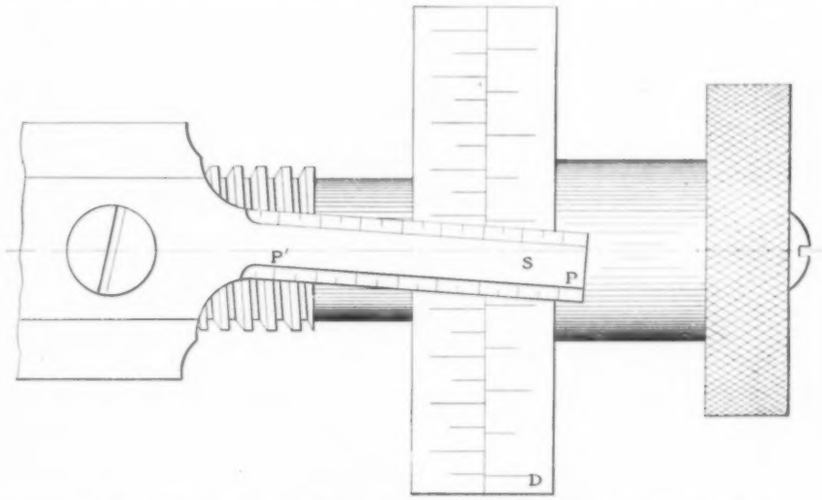


FIG. 37. COMPENSATING FOR ERROR IN SYRACUSE BENCH MICROMETER SCREW

METHOD OF ILLUSTRATION

For the purpose of explanation a vernier for reading tenths from a scale which is divided into whole inches is probably better than a fine one, though no one would think of actually making such a vernier. The size of our page prevents showing such a vernier full size, and Figs. 38, 39, and 40 are, therefore, drawn to reduced scale, but the divisions of the beam are to be considered as inches. To make the illustrations more realistic, the fixed and sliding jaws of a caliper are sketched in.

DIVISIONS OF THE BEAM AND SLIDING JAW

The inch divisions are shown upon the beam of the caliper and the sliding jaw is made so long that its open side will a little more than span 9 inches of space. Upon the beveled edge of the sliding jaw two lines 0 and 10 are shown, these marks being at a distance apart which covers *nine* inches on the beam, these nine inches being then divided into *ten* equal spaces forming the vernier, each space of which obviously equals 9/10 of an inch. The caliper in Fig. 38 is shown set with the 0 mark of the vernier coinciding with the 2 mark of the beam and the jaws are therefore open by 2 inches. This 0 mark of the vernier is read precisely as though the other divisions of the vernier were not there. If set at 3, the caliper is open by three inches, and so on for any other division.

READING THE VERNIER

Comparing 1 of the vernier with 3 of the beam, it is clear that as the space from 2 to 3 of the beam equals 1 inch, while the space 0 to 1 of the vernier equals 9/10 inch, the space between 1 of the vernier and 3 of the beam equals 1/10 inch. Similarly, space 2 to 4 of the beam equals 2 inches and 0 to 2 of the vernier equals $9/10 \times 2 = 18/10$ inch, and hence the space between 2 of the vernier and 4 of the beam equals 2 less 18/10, or 2/10 inch. In the same way the space between 3 of the vernier and 5 of the beam equals 3/10 inch, the space between 4 of the vernier and 6 of the beam, equals 4/10 inch, and so on.

AN IMPORTANT FEATURE

Moreover, these readings of the vernier do not depend upon which beam division the 0 of the vernier rests. With the vernier zero set at any graduation, the number of tenths by which any mark of the vernier falls short of the division of the beam next past it is always given by the number of the vernier division. Now, if the space between 1 of the vernier and 3 of the beam is 1/10 inch, it is only necessary to slide the jaw along, as in Fig. 39, until 1 of the vernier matches 3 of the beam to make the vernier read 2 1/10 inches. Similarly as in Fig. 40, if the jaw be slid along until 0 of the vernier has passed 4 of the beam and 5 of the vernier matches 9 of the beam, the reading is 4 5/10 inches.

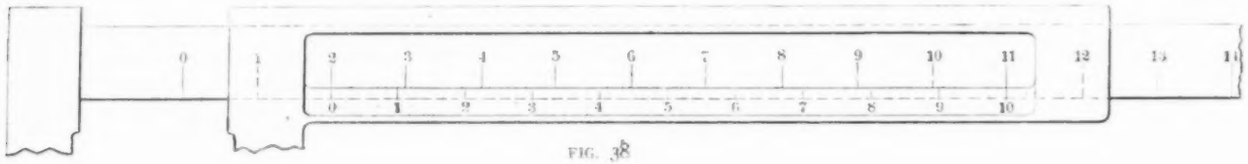


FIG. 38

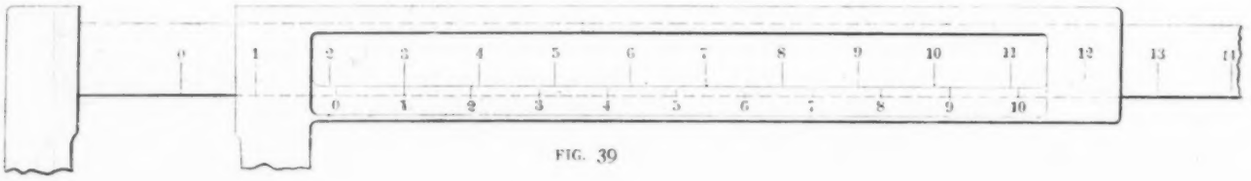


FIG. 39

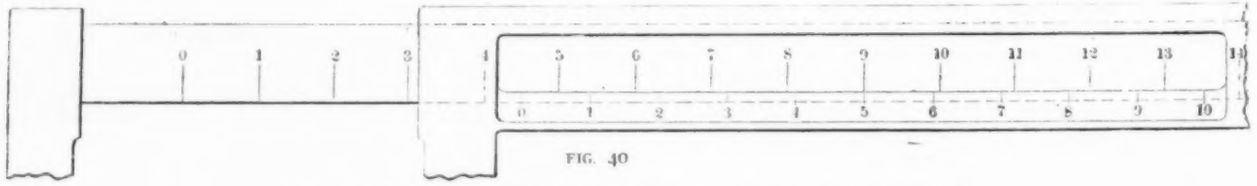


FIG. 40

VERNIER FOR READING TENTHS FROM A SCALE DIVIDED INTO WHOLE INCHES

SETTING THE INSTRUMENT

To set the vernier for any reading, as for instance 6 7/10 inches, it is only necessary to slide the jaw until 0 of the vernier is at 6 and then slide it farther until 7 of the vernier coincides with one of the beam divisions. As 1 of the vernier passed 7 of the beam, the reading was 6 1/10, as 2 of the vernier passed 8 of the beam the reading was 6 2/10, as 3 of the vernier passed 9 of the beam the reading was 6 3/10, and so on until 7 of the vernier reaches 13, when the reading is 6 7/10. Similarly, if the vernier has been set by applying it to a piece of work, it is read by first noting the last whole inch of the beam which was passed by 0 of the vernier, and then glancing along the vernier until a division is found which coincides with a mark of the beam, when the number of that vernier division will give the number of tenths to add.

THE FINENESS OF THE READINGS

The fineness of the vernier readings is found by dividing the divisions of the beam by the number of divisions in the vernier. Thus in Figs. 38, 39 and 40 the beam is divided into inches, and the number of divisions of the vernier is 10. Dividing 1 by 10 gives 1/10 inch as the fineness of the vernier readings. Similarly, if the beam is divided into 1/10-inch spaces, and the vernier has 10 divisions, the fineness of the vernier readings is $1/10 \div 10 = 1/100$ inch, and so on.

THE BROWN & SHARPE SYSTEM

In making calipers to read to thousandths it is desirable to avoid so fine a beam scale as one divided to hundredths, and to do this the Brown & Sharpe Manufacturing Company divide the beam to fortieths only and then use a vernier with twenty-five divisions. Following the above rule gives $\frac{1}{40} \div 25 = \frac{1}{1000}$ as the vernier reading.

Fig. 41 shows the Brown & Sharpe vernier to an enlarged scale, and it will be easily understood after what has preceded. The inch will be seen to be divided into tenths and each tenth into four parts, the value of each part being obviously 1/40 or 0.025 inch. Twenty-four of these parts are then divided into 25 spaces on the vernier. In the illustration the 0 of the vernier has passed the first tenth, and the second subdivision. As the value of each subdivision is 0.025 the value of two of them is 0.05, and if the 0 of the vernier stood at the second division the reading would be $0.1 + 0.05 = 0.15$. To find how many

thousandths must be added to this for the setting shown, we run the eye along the vernier and find that coincidence between the divisions of beam and vernier occurs at the twelfth division of the latter, which gives 12 thousandths for the addition. Making this addition we have $0.15 + 0.012 = 0.162$ as the reading.

THE COLUMBIA CALIPER

E. G. Smith, of Columbia, Penn., makes a vernier caliper in which the beam is graduated to sixteenths and the vernier has eight divisions. The reading is therefore $\frac{1}{16} \div 8 = \frac{1}{128}$ inch. This caliper is shown in Fig. 42, again to an enlarged scale. The reading of this vernier is as simple as those first described. As engraved, the 0 of the vernier has passed the 5/8 mark of the beam, and glancing along the vernier the coinciding lines are found at the third graduation, and the reading is therefore $\frac{5}{8} + \frac{3}{128}$.

ARRANGEMENT FOR DIRECT READING IN CALIPERING HOLES

This caliper has a very ingenious arrangement for direct reading when calipering a hole. The widths of the jaws *a* and *b* are such that together they are equal to the length of the vernier—that is, 7/16 inch. This being the case, while the extreme left-hand graduation of the vernier gives the distance *c*, the extreme right-hand graduation gives the distance *d*, the value of the vernier readings being, however, obtained by counting from the left in both cases. It is obvious that if the left-hand graduation stood at 5/8 the right-hand one would stand at 1 1/16, these being the measurements for plugs and holes respectively. Advancing the jaw to the position shown affects both readings alike, and while the plug measurement is $\frac{5}{8} + \frac{3}{128}$ the hole measurement is $1\frac{1}{16} + \frac{3}{128}$.

EARLY HISTORY OF THE MICROMETER CALIPER

A French Invention and Some Later American Designs

Some years ago, in taking up the early history of the micrometer caliper, we published some interesting correspondence between the Brown & Sharpe Manufacturing Company and others relating to this matter. We reprint below part of the contents of a letter written in 1887 by Mr. Sharpe to F. A. Strong, of Bridgeport, Conn.

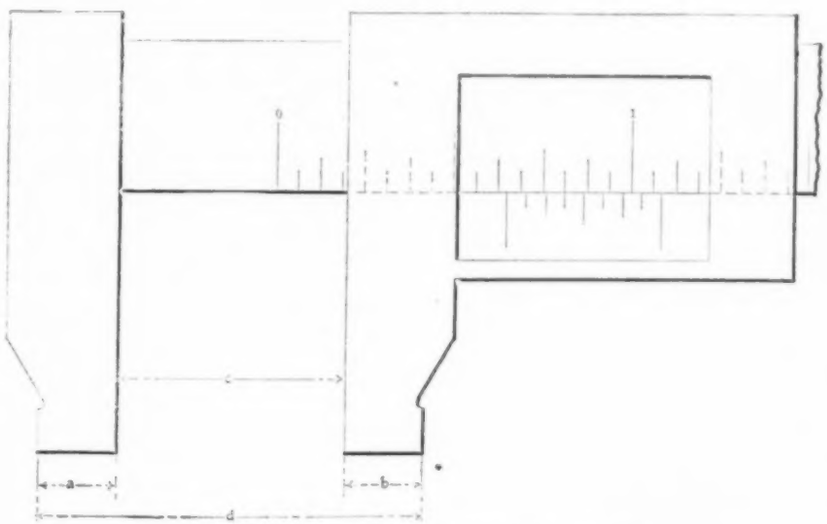


FIG. 42. THE VERNIER OF THE COLUMBIA CALIPERS

ABSTRACT OF MR. SHARPE'S LETTER

We take pleasure in telling you the history of the micrometer caliper as far as our knowledge extends. Some time in the first seven months of 1867 a man connected with the Bridgeport Brass Company brought a gage here of the size and form of the smallest tool shown on the blue print herewith inclosed [Fig. 43] and desired to have some made. It was invented by someone employed in that establishment, we were told. The reading of thousandths of an inch was done by means of a spiral line of the same pitch as the screw, 40 to the inch, running round the cylindrical head of the screw, crossed by 25 lateral lines, dividing this head into 25 equal parts. The pointer which is attached to the body of the instrument shows where the lines intersect; and if you count the number of screw-thread lines the pointer has passed over, added to the number of lateral lines, the number of

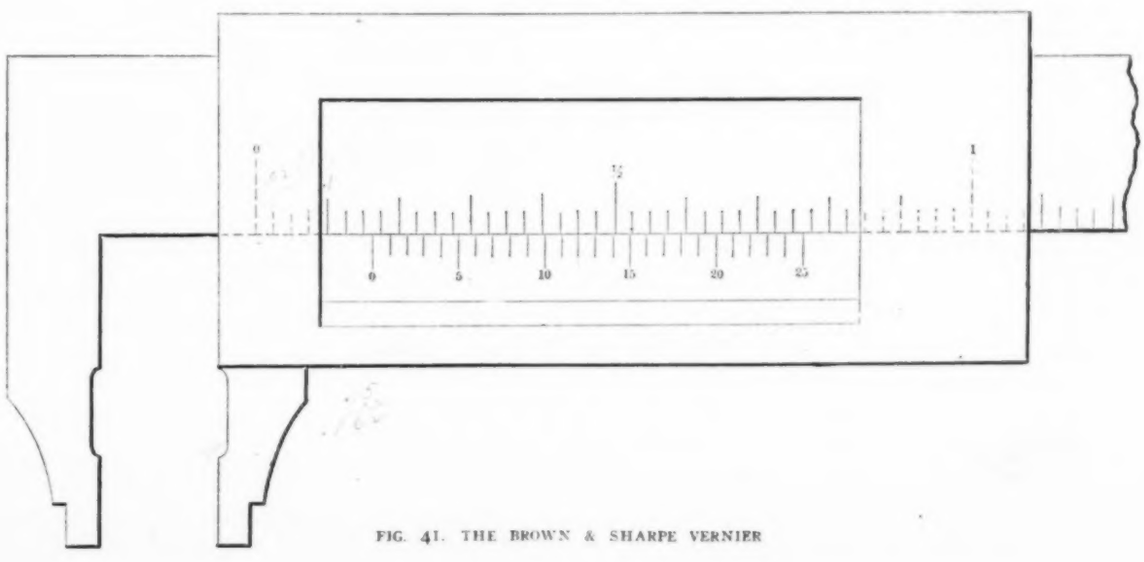


FIG. 41. THE BROWN & SHARPE VERNIER

thousandths of an inch the caliper is open can be obtained; but, as the cylinder is so completely covered by the crossed lines, rendering it impossible to put any figures upon it, we did not at the time consider the instrument of practical value, as it could not be easily read. In August, 1867, our Mr. Brown and the writer visited the Paris Exposition and there saw a micrometer caliper like the other tool shown on the blue print [Fig. 44], and brought one home with us. It was at that time

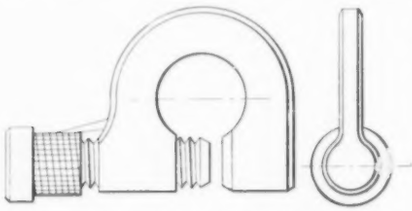


FIG. 43. AN EARLY FORM OF MICROMETER

well known in France as "Systeme Palmer," or Palmer's plan of gage, from the name of the inventor. As a gage was wanted for measuring sheet metal, we adopted Palmer's plan of division and the Bridgeport man's size of gage, adding the clamp for tightening the screw and the adjusting screw for compensating the wear of ends of points where the metal is measured, and produced our "Pocket Sheet Metal Gage."

As to whom the credit is due for producing the "Pocket Sheet Metal Gage," you can determine from the above statement of facts. We never should have made such a gage as was shown us by the Bridgeport man in 1867 to sell on our account, as it would be too troublesome to read to be salable. If we had not happened to find the Palmer gage, and thereby found a practical way to read thousandths of an inch, no gages would have been made. If we had never seen the Bridgeport device we should have found the Palmer at Paris, and without doubt have made such gages, but possibly would have made a larger one first. The immediate reason of making the "Pocket Sheet Metal Gage" was the suggestion coming from the Bridgeport Brass Company of the want of a gage of the size of the sample shown us for the use of the brass trade.

FURTHER PARTICULARS

In addition to Mr. Sharpe's letter, as given above, we also printed at the time an article written for the *American Engineer* by W. D. Forbes, of Hoboken, N. J., on the origin of the micrometer. Some interesting points were brought out in the article as follows:

MR. FORBES' ACCOUNT

In 1867 the Bridgeport Brass Company, Bridgeport, Conn., in furnishing sheet metal to the Union Metallic Cartridge Company, of the same place, had a lot of brass returned as out of gage. On investigation it was shown that the brass was to the gage of the brass company, but that the gage in the hands of A. C. Hobbs, of the cartridge company, and the one in the hands of S. Wilmot, of the brass company, did not agree; in short, all three gages were proved by a fourth to be out. Mr. Wilmot saw at once that the same thing might be constantly occurring, and he said to Mr. Hobbs: "We will make this lot of brass to your gage, but hereafter I will furnish all sheet metal to a given thickness, but you must allow me a certain variation, either above or below it, as we cannot, of course, turn out absolutely perfect work. Now, what percentage will you allow?" Mr. Hobbs thought it over and agreed to allow a plus or minus variation of 5 per cent; "but," said he, "I don't see how the percentage can be satisfactorily determined."

Mr. Wilmot answered he was tired of depending on a slit in a piece of metal for sizes, and would bring Mr. Hobbs a measuring instrument which would at once give percentage. Returning to his shop, Mr. Wilmot sketched the micrometer very much as now made [1892] by the Brown & Sharpe Manufacturing Company, with these exceptions: the stem through which the screw passed was not split as now; the end of the screw was not hardened, nor was the fixed abutment, against which the article to be measured is placed, made adjustable for wear. But the thread of the screw was 40, and the division of the barrel 25, as now made. A pointer fixed to the main frame stood in the place of the present center line (see Fig. 45).

A. D. Laws was then in charge of the mechanical work of the Bridgeport Brass Company, and to him Mr. Wilmot gave the sketch and told him to have six made. Mr. Laws gave the work to a very skilled machinist by the name of Hiram Driggs, who made them. These are in existence today; at least, one of them is in use, and is in the possession of Mr. Laws. The Brown & Sharpe Manufacturing Company received permission from Mr. Wilmot to make the micrometer, not that he claimed any patent or exclusive right to it, as the idea he thinks he got from a gage which he saw in the works of the well known printing-press makers, Hoe & Co. In the year 1867 L. Sharpe, of the Brown & Sharpe Company, bought a micrometer gage at the Paris Exposition, and as it was called "Systeme Palmer," it is to be supposed that a man by that name originated it. This micrometer, Mr. Sharpe says, is practically what they now make.

The instrument that Mr. Wilmot saw at Hoe's was mounted on a bench and had a wheel and screw, the wheel being divided. The trouble which was encountered when the end of the screw was hardened by the thread warping was overcome by the Pratt patent [owned by Brown & Sharpe], which made the end of the screw to receive a hardened plug by drilling a hole in it and forcing the plug in. This was a most valuable idea, and, to get around it, it is stated that a firm made a pin on the end of the screw and forced on it a hardened cap; but the law called it "substantially as described" in the Pratt patent, and sat on the firm.

A FRENCH PATENT

Following the publication of the foregoing particulars given by Mr. Sharpe and Mr. Forbes, we received from Brown & Sharpe a copy of the patent issued to

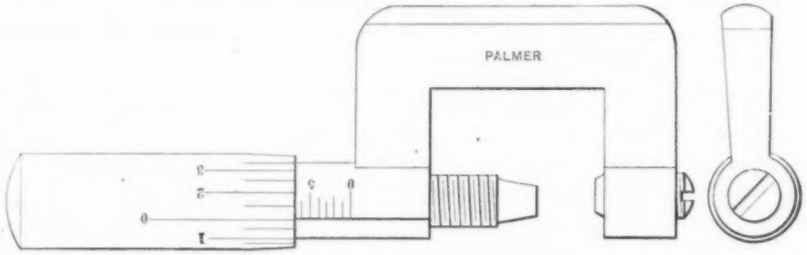


FIG. 44. A FRENCH MICROMETER

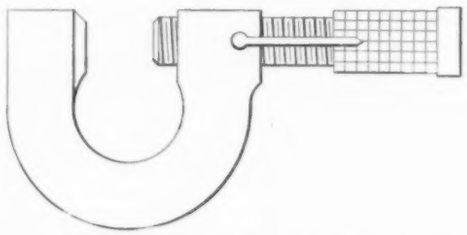


FIG. 45. ANOTHER EARLY DESIGN

"citizen" Palmer of Paris in 1848, the translation being as follows:

MINISTER OF AGRICULTURE AND COMMERCE

PATENT OF AN INVENTION WITHOUT GOVERNMENTAL GUARANTEE

To the Minister of Agriculture and Commerce

In accordance with the law of July 5, 1844.

In accordance with this law, on September 7, 1848, at 3 o'clock and 5 minutes,

a citizen named Palmer demanded of the secretary of the Department of the Seine a patent for fifteen years on a screw caliper with circular vernier. In consequence of the regularity of this demand, it is decreed as follows:

ARTICLE FIRST

To Jean Laurent Palmer, a machinist of Paris, 16 Rue Montmorency, on the 7th day of September, 1848, is guaranteed a patent for fifteen years on a screw caliper with circular vernier, the same being guaranteed to him at his own risk and peril without any examination as to its value or

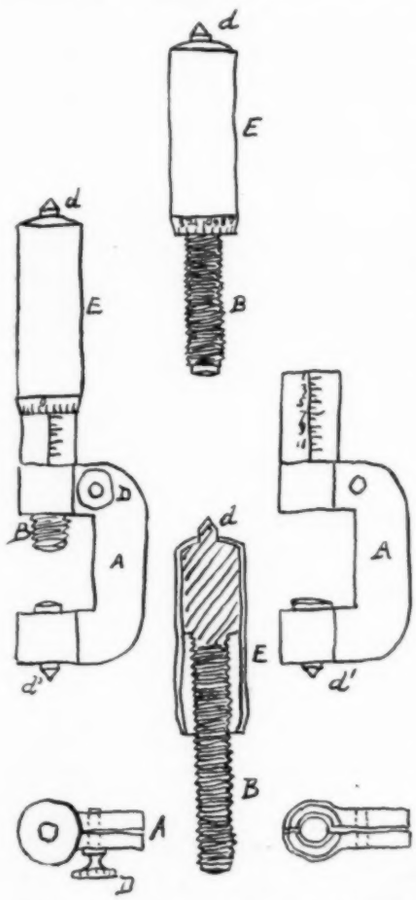


FIG. 46. THE PALMER MICROMETER AS SHOWN BY A FRENCH PATENT DRAWING OF 1848

novelty, or to the fidelity or exactness of this description.

ARTICLE SECOND

This decree constitutes a title to this citizen Palmer for his invention, and to this decree are affixed duplicate certificates of the drawings and descriptions deposited by him in support of his original statements, which are hereby duly established.

THE MINISTER OF AGRICULTURE.

Paris, Sept. 7, 1848.

THE PATENT DRAWING

In the engraving, Fig. 46, the sketches which accompanied this patent are reproduced as nearly as possible, the original letters of reference being kept on.

CALIBRATION OF TWO BROWN & SHARPE MICROMETER CALIPERS

An Account of some Tests Made by College Students

The value of the following account of a test to which two micrometers were put some years since consists mainly in the description of the method of making the test, though the results obtained are interesting, especially as they have some bearing upon a question which has been discussed in our columns. The makers of the micrometers seem to have had nothing to do with the test, for if they had, they of course would not have been willing to stake the reputation of their calipers upon a test of two instruments that had been in use for about a year, especially if, as we infer, this use was in the school and by a number of different persons, most of them unused to handling micrometers. Considering this, the results given, i.e., an error on one caliper of 0.00012 inch and on the other of 0.00036 inch, must be considered as quite creditable. As we said, before, however, the principal point of interest is in the method of making the test, for the results do not show the degree of accuracy attained in such calipers, nor do they show the wearing qualities, because the original errors are unknown. The description of the method and results, as originally given in the *Crank* by the students who made the test, is as follows:

MICROMETER CALIBRATION

The calibration of a micrometer caliper which is considered a standard instrument is a matter of interest to all users of micrometer screws, since such a calibration will show to a considerable degree of accuracy whether the micrometer is perfect, or in error, and if the latter, the nature and extent of the error. Being interested to know to what extent the instruments used in the mechanical laboratory at Sibley College could be relied upon, at the suggestion of Prof. R. C. Carpenter the following investigation was made.

The calibration was effected by comparison with a standard metallic grating upon the Rogers-Ballou comparator. The caliper was rigidly clamped to the comparator, the axis of the screw being horizontal and parallel with the ways of the machine. The plug which forms the lower post of the caliper was removed. An iron block having a ¼-inch rod screwed into one side was clamped to the small movable carriage in such a way that the rod played freely through the hole in the caliper and abutted against the end of the micrometer screw. The metallic grating was mounted upon this carriage.

When the micrometer screw was advanced it pushed the carriage carrying the grating before it, and the absolute amount of such displacement was read by means of a fixed microscope focused upon the grating. A similar microscope served to show whether the caliper remained absolutely stationary throughout the investigation. Precautions were taken to secure perfect alinement of the parts by adjusting the cross-hairs of the microscope upon the axial graduation line of the caliper, and requiring it to traverse the whole length without deviation or going out of focus. This insured alinement in both horizontal and vertical planes.

The grating used consists of a bar of metal highly polished on one side and ruled 2500 lines to the inch. The reading microscope is provided with two cross-hairs, one fixed and the other adjustable by means of a micrometer screw, the head of which is divided into 100 parts, each representing a displacement of 0.00001 of an inch. Increments of even number of thousandths were taken, so that at each reading the fixed cross-hair should coincide with one of the lines of the grating. Any variation from this was measured by bringing the movable cross-hair into coincidence with the line of the grating corresponding to the reading of the caliper, and reading its displacement from the fixed cross-hair, thus determining the error of the screw.

The investigation showed that the micrometer screw could be adjusted to within 1/50,000 of the desired point. There was also a possible error of about the same amount in reading the grating, thus making a total possible error of 1/25,000. Readings were taken throughout the length of the screw with constant increments of 0.024 of an inch. Inasmuch as the head is divided into 25 parts, this brought the reading upon each division successively, thus testing the accuracy of the graduation.

The readings showed little error, beyond that due to observation, throughout the first ¾ of its length (one inch); during the last ¼ of its travel, however, an accumulative error appeared, amounting at the end to 0.00012 inch, the actual length of the screw being 0.99988 inch. A number of readings was taken both of intermediate points and total length. A second micrometer of the same manufacture and pattern was also calibrated in substantially the same manner, showing an error which gradually rose to 0.00025, midway in its travel, dropping at 0.7 to 0.00017 and again rising to a maximum at the end of 0.00036, the error being as in the first case. The screw was therefore too short, its total length being 0.99964 of an inch. The instruments tested were of modern design and had been in use about one year.

A MICROMETER OF THE ORIENT

A Measuring Tool Made by the Superintendent of a Chinese Shop

The half-tone, Fig. 47, shows the two sides of a 1-inch micrometer caliper (after Brown & Sharpe) which will probably look rather familiar, and provoke some curiosity as to why such a very commonly used tool should be illustrated in this connection. A closer inspection, however, will show that the tables of the translation of sixty-fourths of inches into thousandths, which are now usually stamped upon the sides of these instruments, have been entirely omitted, and in place thereof certain Chinese inscriptions have been stamped, the meaning of which is possibly not entirely clear to the ordinary observer, but "thereby hangs a tale."

WHERE THE MICROMETER WAS MADE

The micrometer from which these pictures were photographed is a very fair working instrument, although, of course, not so accurate as its prototype made in Providence, from which it was copied, and which is now in use in a machine shop in the interior of China, nearly 2000 miles westward from Shanghai. This shop runs some 50 or 60 men, and is attached to the government arsenal and mint at Chentu. These machinists, as well as their gang bosses, foremen, superintendent and general manager, together with the 400 or 500 other operatives of the establishment, are all native Chinamen, with no English-speaking people about them, there being no Europeans except a few missionaries (if they are still alive) in the whole of the city mentioned, which has a population of some 800,000.

AN EXCHANGE OF INSTRUMENTS

The American micrometer was exported in the pocket of Henry A. Janvier, who, a few years ago was sent to China by the Ferracute Machine Company to help finance that country by superintending the erection and running of certain coining plants for making all the new silver and brass coinage of the province of Szchuen. The very intelligent shop superintendent, Mr. Wai, whose name appears in his native language in one of the inscriptions referred to, was delighted with the Brown & Sharpe micrometer, never having seen one before, but fully appreciating its usefulness. He borrowed it at numerous intervals extending over a period of six weeks, not always returning it when it was wanted, without some urging. At the end of that time he brought Mr. Janvier the instrument of the pictures, with a request that a "swap" be made. This proposition was favorably considered, as a tool of this kind made by native machinists, who had never seen one before, and entirely by hand, or with the ordinarily crude machine tools attainable, was indeed too much of a curiosity to ignore. The contract, therefore, was gleefully executed by both the parties of the first and second parts.

ORIENTAL WORKMEN

It will probably be a surprise to many of the readers of this article that so good mechanical work as this is, and as are the tools which are constantly being made for arsenal work, can be produced by native brains and labor in the out-of-the-way location referred to. It is true that the old-fashioned, crude machine tools and engine in use in this arsenal were made in Europe, and that some time the Chinamen may have been instructed in their use, but it is a certain thing that they seem to take kindly to accurate mechanical work, providing they do not have to design it themselves.

When the coining machinery in question had been set up and started, there seemed to be no difficulty in teaching the native workmen, in a few days' time, to operate it successfully, or to take it apart, put it together, adjust it and repair it.

It is an easy matter to provoke a laugh at the expense of the man who measures the width of a door by stretching his hands apart till the finger tips exactly reach the extreme edge, and then, walking away, says: "Don't get in my way; I've got the width of a door here." Much the same may be thought of the man who uses thumb and finger to get the size of a shaft, or to determine if it is round; or who with thumb and finger twirls a piece of wire between his teeth and decides whether it is round. These are plain subjects for actual measurement; but there are many other tests, as in the assorting of wool or other fiber, the inspection of bank notes for detection of counterfeits, the inspection of fracture in metals to determine structure, quality and condition, comparison of shapes not easily gaged or measured, in which accuracy of judgment is acquired that is truly wonderful.

Is it not, however, guess work? It certainly is not infallible, as would be proven by actual measurement in any case where the measuring test could be applied.

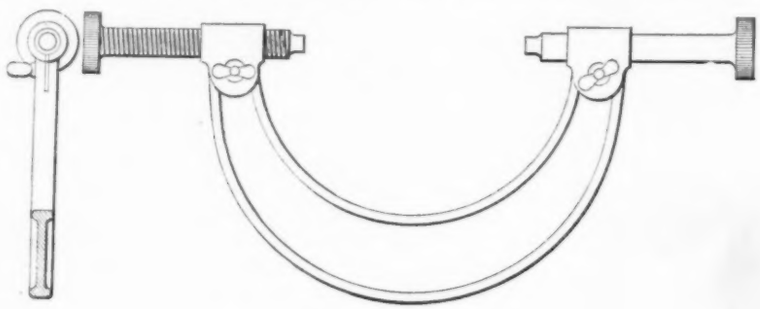


FIG. 48. A MICROMETER SNAP GAGE

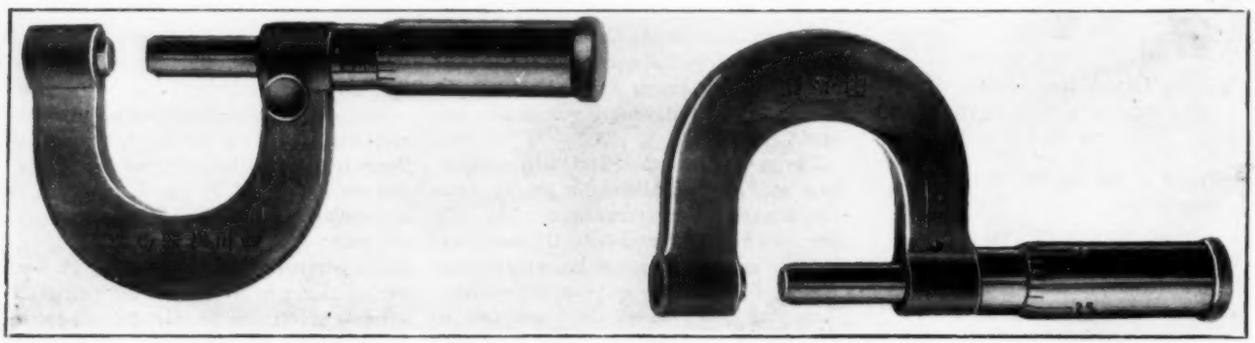


FIG. 47. A MICROMETER OF THE ORIENT

THE USE OF MICROMETER CALIPERS FOR REGULAR SHOP GAGES

A Tool Manufacturer Expresses His Ideas upon This Subject, and Another Contributor Describes a Handy Micrometer Gage

THE MANUFACTURERS' ARGUMENT

In the early days of the machinist business, there were no means at hand for working closely to any standard of dimensions, and very little effort was made beyond the making of different parts to fit each other. Some people may think it impossible to make work interchangeable in this way, but, of course, there is a way to do it. It has been done quite successfully by first constructing a successful machine as a model, then taking it down and using its parts as standards.

WHERE THE SYSTEM FAILS

This plan works fairly well for a single shop, until there is a fire. When it comes to some other shop duplicating work, or making repairs, the system does not work so well. In the earlier days some very short-sighted persons thought this plan would work to their own advantage by forcing people to go to them for all repairs. Clearer headed people see, with modern means of measuring, that a hole approximately one inch might better be near enough to fit a standard arbor or reamer, and that a tap 1/64 inch over half-inch in diameter might as well be half-inch, near enough to agree with some other fellow's tap, and that such things must make their machinery more valuable and lead to further orders from satisfied customers.

THE ADVANTAGE OF A STANDARD

The advantage of following our standard of inches is that it is a means by which we can talk intelligently and order intelligently. Everyone knows what an inch is in theory. When I say, "Make work one inch in diameter," I do not mean the theoretical but the practical, the near enough for the purpose, near enough to fit the standard arbor, or some other fellow's arbor. This limit may be 0.001 inch more or less. It is not difficult or expensive to reach this, using modern appliances. I have heard it said, not long ago, that the best modern mechanics are not the ones who have "good enough" for their motto.

THE "GOOD ENOUGH" IDEA

The modern or ancient mechanic who does not or who did not have "good enough" for his motto is a very poor "stick," a man whom no machine shop can afford to have around; in fact, he is no mechanic at all. A mechanic undertakes to construct a machine to fulfil certain conditions, and if he continues to monkey with it one minute after it fulfils these conditions properly, he is wasting money. This "good enough" cuts a big figure in the standard measurement business. It is the connecting link between Success with a big S, and failure. I have seen machine shops, in their endeavors to adopt standard sizes, act very foolishly and waste considerable money, merely because they did not grasp this "good enough" idea.

WHAT "GOOD ENOUGH" ACTUALLY MEANS

This "good enough" is not something to be guessed at; it is something to be measured, something to be dealt with intelligently. It is our allowable limit, our measure of how far the work can vary from standard and still be used successfully. This allowable limit enters into all classes of work. In some cases in navigation it may be a matter of ten or fifteen miles, and in fine gage work it may mean 0.0001 inch or less; but the limit must exist just the same. We must have some means of knowing when work is near enough if we want to do business and live.

THE OBJECT OF GAGES

When we use a solid gage or a snap gage, it stands for the size in theory all right. It answers one question: Is the work theoretically correct? If too large, make it smaller; but what about too small? Perhaps it will go, if we had something to tell how small it is. Perhaps you have limit gages, two sizes: to go through, and not to go through. This is much better, for you know then whether to throw the work away or not. The limit gage can be made to answer the final question: Shall we save it or throw it away?

THE LIMIT-GAGE QUESTION

Now, this same limit-gage business is very complicated, and it is also expensive, when carried out to the extent necessary to get anywhere with it. It does not, and cannot, answer all questions. You give a man a limit gage to turn a piece of work to. He says: "This piece is a certain size now; if I know what size it is, I can form an idea of how much there is to come off." This is worth knowing. He wants some means of measuring the piece just as it stands. The fellow who ignores "good enough" doesn't care. He will start nibbling that piece up into atoms. It won't do to take a big chip, for fear of getting it too small. You must have patience with him. The mechanic of today wants a means of measuring his work during the process of finding the right size.

THE MISSION OF THE MICROMETER

The micrometer caliper with graduated disks on machines fulfils the requirements quite well. I do not mean to say, buy a lot of them and throw them into the shop, and that then things will right away start off like a summer night's dream. This would be too much to expect of even a good thing. There are some brains required along with them. I have never seen a machinist who, after undertaking the use of a micrometer, was not improved by it in many ways. His "littles" soon come to be expressed more intelligently. He commences to measure, where he formerly guessed, with a consequent improvement all around.

THE ITEM OF FIRST COST

A shop is improved by introducing micrometers even on a small scale. Jones says they are too expensive, but it seems that Jones has not figured very accurately. If he figures what limit gages will cost, to do even a small part of what the micrometer will, he will find the micrometer a very cheap tool in comparison. Then, again, the demand has much to do with the cost. If micrometers were used to the extent that they should be, there would be a demand for hundreds of times more than at present, and this would naturally reduce the price.

ANOTHER UNFOUNDED OBJECTION

Smith says the greatest trouble is that they are too light and tender, too liable to get out of order, in the hands of all classes of help. Smith's ideas are the most common. Probably there are some differences in makes, but it makes a great difference how they are handled. In the snap gage there is no provision to show how large a piece is until the gage goes over. Most machinists want earlier information, and so they force the gages, in hope to tell, by the sense of touch, how much remains to come off. This sense of touch differs in people very much. In some it amounts to all their strength, and these strong ones spoil the gages.

MICROMETERS NOT LIKELY TO BE ABUSED

In the micrometer there is no excuse or use for so much strength. It is adjustable; the machinist may know, by its reading, when the work is correct; he may also run the screw back and measure, without crowding, the actual size at any stage. In the case of the micrometer the man uses his brains and his eyes more, and saves his strength for riding a bicycle or other work where strength is useful. I have found it easy to teach men to use micrometers. I have had experience in running a shop (on a small scale) for many years, and have used nothing in the way of gages, on close work, but micrometers. If it can be done on a small scale successfully, why not on a large one?

ABSOLUTE PERFECTION REQUIRES CARE AND JUDGMENT

Mr. Perfection says that no two men can measure alike with a micrometer. This is serious. There is a funny thing

comes in right here. Men who have worked perhaps twenty years at the business, and who perhaps have never worked closer than 0.002 inch in their lives, unless by accident, when they get to using micrometers, will sometimes get it into their heads that if they can't work to absolute perfection it is of no use; when nearly as close work as, with their best efforts, they have been in the habit of doing, can be done with the micrometer with almost no effort. Where great accuracy is required, great care must be taken with the gages, whatever kind they may be.

THE USE AND CARE OF MICROMETERS

Along with micrometers, in every shop, there should be a good set of solid test pieces, end measures or disks. Someone should be detailed to look out for the adjustments of all the micrometers in the shop. This someone should be skilled in such work. It should not be left to everybody. Where very close results are required, two sets of test measures should be kept, one for general use, the other for occasional reference only. Some of the micrometers should be kept for the finest work only, where those that are more worn or otherwise more inaccurate can be used on work of less refinement. I believe in graduated disks fitted to the feed screws of all machine tools. If the micrometers in use are graduated to read in thousandths of an inch, these dials should also read the same.

A HANDY GAGE DEVISED BY ANOTHER PRACTICAL MAN

In connection with the preceding matter pertaining to the use of the micrometer as a regular shop gage, we believe the following account of some home-made adjustable gages, as related by the man who constructed them, should be of interest:

The accompanying sketch, Fig. 48, shows an adjustable snap gage that I have used for several years as part of a shop system of measurement that I have found very satisfactory. These gages can be made at a very small cost, especially if a number of them be made at the same time. The one shown here will take in anything up to 3½ inches, a size of gage most general in lathe work. The frame is of cast steel, very light and rigid; the rod and screw are 5/16 inch in diameter, the latter having 20 threads per inch and locked when adjusted by the thumb-screws shown.

ALINEMENT OF ROD AND SCREW

We experienced no difficulty in making the rod and screw come exactly in line. It was done in the following manner: the holes were drilled on the lathe centers and then split with a hack saw whose soft back had been cut down until it would pass through the hole. The holes for the thumb-screws were drilled next, the top half to the whole diameter of the screw, and the bottom half tapped. A cast-iron sleeve, 1½ inches long and ⅞ inch diameter, was then made to fit snugly over the shank of the tap, which had been shortened by cutting off the square end.

TAPPING THE HOLE FOR THE SCREW

The shank was entered one-half the length of the sleeve and a hole drilled through sleeve and tap and fitted with a pin. The hole for the adjustment screw was then tapped from the inside of the gage outward, the shank of the tap being supported in line by a rod passed through the other hole into the sleeve and rigidly clamped by the thumb-screw. The tap was turned by a small bar fitting into holes drilled around the sleeve. The ends of the rod and screw are hardened and ground.

MAKING THE "POINTS"

Under the system which I have employed and found so satisfactory, we used 0.1-inch square steel wire for "points," as the men called them. If a man had certain sizes to turn that had to be quite accurate, he would cut off pieces of this wire about the length required, stamp the size on it and round and taper the ends so that they were about 1/32 inch in diameter. These points he made approximately to size and then gave them to the foreman, who tested them with a vernier caliper in his office, fitting each with a rub or two of the file, or perhaps a blow of the hammer on a small anvil beside the instrument, to bring it up to size. It is then a simple matter when the work is roughed down nearly to size, to quickly and accurately set the snap gage to the point, making practically a solid gage. These "points" are very quickly made, and can of course be kept for future use.

SOME FEATURES OF THE SYSTEM

A man seldom required more than the suggestion that he could get his points ready while his machine was running, before he made a practice of doing so. For sizes over 10 inches we used a piece of broom handle or other wood, with a pointed wood screw in either end, flattened for a wrench. When extreme accuracy was necessary in the smaller sizes, a small piece of wood was drilled out and pressed over the wire to keep the heat of the fingers from expanding the gage while setting. These "points" can't be beaten for inside gages, especially in getting the size of a hole already bored when it is necessary to turn a piece to fit it exactly.

THE GAGES USED BY PREFERENCE

Besides these snap gages we had a number of the regulation micrometer calipers of all sizes in the toolroom, and accessible to anyone competent to use them; but I noticed that it was not long before there was hardly any call for them, even by our best workmen, after they had become accustomed to the new system. I have never known a machinist who had tried the system but who was in love with it; and, besides producing the work within the desired limits, I found the total time consumed much shortened.

MEASURING EXTERNAL SCREW-THREAD DIAMETERS

The Application of Micrometers and Wires in the Measurement of U.S. Standard, 60-degree V, and Whitworth Threads

It is frequently necessary, especially in making a tap or thread-plug gage, to measure the thread diameter on the thread angle in addition to measuring on top of the thread and at the bottom of the thread groove, and unless calipers made expressly for the work are at hand, the measurement on the thread angle is not made with any degree of accuracy or is omitted entirely. The accompanying sketches, Figs. 49, 50 and 51, formulas, and Table 10, are worked out for convenience in screw-thread inspection, so that by using ordinary micrometer calipers and wire of the diameter called for in the table the standard threads can be compared with the figures given.

THREADS OF SPECIAL DIAMETER

For threads of special diameter the values of x, x_1 or x_2 can be readily computed from the formula corresponding to the method of measuring to be used. The method shown in Fig. 49 at x is liable to lead to an error unless care be taken that the diameter on top of the thread is correct, and also that the flatted surface on the top of the threads is concentric with the rest of the thread. The concentricity of the flatted surface can be tested by measuring, as at x, Fig. 49, at several points on a plane through the axis and at right angles to the same. The wire used must be round and of uniform diameter.

DIAMETER AT ROOT OF THREAD

An important point not understood by all draftsmen, toolmakers and machinists is the fact that the dimensions for diameter at the root of the thread obtained from the formulas which are in general use, viz.:

$D - \frac{1.299}{n}$ for U. S. standard threads,

$D - \frac{1.732}{n}$ for 60-degree V threads,

and

$D - \frac{1.28066}{n}$ for Whitworth,

do not give the correct diameter for measuring the bottom of the thread groove,

but instead they give the diameter of a cylinder which the point of the threading tool will touch when it has reached the correct depth of the thread. The formula which gives the diameter for measuring at the bottom of the thread groove is

$$\sqrt{(D-2d)^2+\left(\frac{Lead}{2}\right)^2}$$

and the various root diameters given in the three columns headed D_1 in the accompanying table were computed from this formula.

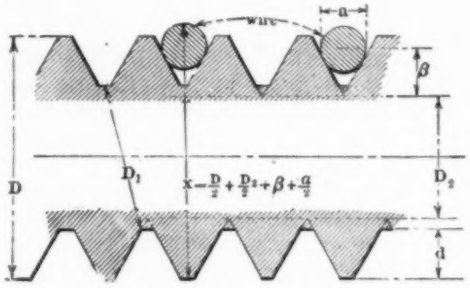


FIG. 49

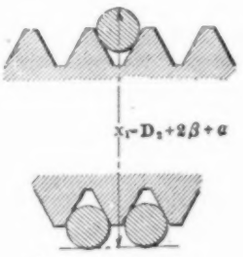


FIG. 50

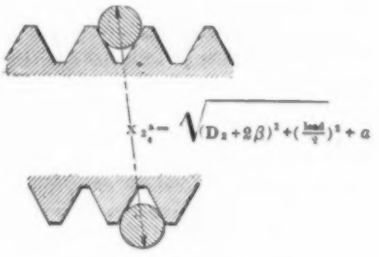


FIG. 51

Let D=outside diameter of thread.
" D_1=root diameter measured in thread groove.
" n=number of threads per inch of length.
" d=depth of thread.
" p=distance from center to center of adjacent threads.
" f=width of flat on U. S. Standard thread.
" r=radius on Whitworth thread.
" a=diameter of wire used.
" β=distance from apex of thread angle at root, to center of wire.
" D_2=diameter of cylinder touched by apexes of thread angles.
" x=diameter from top of threads on one side of tap or bolt, to top of wire laid in thread groove on opposite side.

U. S. STANDARD THREAD.

Then p=lead=$\frac{1}{n}$ for single threads.

$d=p\times.6495=\frac{.6495}{n}$

$D_1=\sqrt{(D-2d)^2+(\frac{lead}{2})^2}$.

$f=\frac{p}{8}$

a=from p. max; to p x .505, min.

$\beta=\frac{p}{8}\div\sin 30°=p$

$D_2=D-\frac{1.0825}{n}$

$x=\frac{p}{2}+\frac{D_2}{2}+\beta+\frac{a}{2}$.

$x_1=D_2+2\beta+a$.

$x_2=\sqrt{(D_2+2\beta)^2+(\frac{lead}{2})^2}+a$.

60° V THREAD.

p=lead=$\frac{1}{n}$, for single threads.

$d=p\times.866=\frac{.866}{n}$

$D_1=\sqrt{(D-2d)^2+(\frac{lead}{2})^2}$

a=.$\frac{2}{100}$, max; to p x .577, min.

$\beta=\frac{p}{4}\div\sin 30°=a$.

$D_2=D-\frac{1.732}{n}$.

$x=\frac{p}{2}+\frac{D_2}{2}+\beta+\frac{a}{2}$.

$x_1=D_2+2\beta+a$.

$x_2=\sqrt{(D_2+2\beta)^2+(\frac{lead}{2})^2}+a$.

WHITWORTH THREAD.

p=lead=$\frac{1}{n}$, for single threads.

$d=p\times.64033=\frac{.64033}{n}$.

$D_1=\sqrt{(D-2d)^2+(\frac{lead}{2})^2}$.

r=p x. 1373.

a=p x. 84, max; to p x. 454, min.

$\beta=\frac{p}{4}\div\sin 27°30'=\frac{p}{.7317}$

$D_2=D-\frac{1.280323}{n}$.

$x=\frac{p}{2}+\frac{D_2}{2}+\beta+\frac{a}{2}$.

$x_1=D_2+2\beta+a$.

$x_2=\sqrt{(D^2+2\beta)^2+(\frac{lead}{2})^2}+a$.

D	n	D_1	D_2	a	β	$(\frac{lead}{2})^2$	x	x_1	x_2
¼"	20	.1887	.1743	.°04	.04	.000635	.3721	.3943	.3935
5/16"	18	.2419	.2283	"	"	.000771	.4304	.4483	.4495
⅜"	16	.2934	.2803	"	"	.000978	.4876	.4998	.4016
7/16"	14	.3485	.3299	"	"	.001274	.4433	.4492	.4507
½"	14	.4019	.3844	.°06	.06	.001479	.5317	.5434	.5447
9/16"	12	.4581	.4362	"	"	.001735	.5893	.6162	.6177
⅝"	11	.5089	.4872	"	"	.002065	.6461	.6672	.6681
11/16"	11	.5712	.5497	"	"	.002065	.7096	.7297	.7313
¾"	10	.6221	.5984	"	"	.0025	.7643	.7764	.7801
13/16"	10	.6844	.6609	"	"	.0025	.8287	.8409	.8435
⅞"	9	.7327	.7083	0.°10	0.°10	.003086	.8408	1.0068	1.0083
15/16"	9	.7950	.7691	"	"	.003086	1.0033	1.0691	1.0706
1"	8	.8399	.8105	"	"	.003906	1.0533	1.1106	1.1134
1 1/16"	7	.9421	.9085	"	"	.005102	1.1667	1.2085	1.2107
1 ⅛"	7	1.0668	1.0335	"	"	.005102	1.2917	1.3335	1.3355
1 3/16"	6	1.1614	1.1234	"	"	.006944	1.3967	1.4324	1.4350
1 ¼"	6	1.2862	1.2474	"	"	.006944	1.5227	1.5474	1.5497
1 5/16"	5½	1.3917	1.3494	0.°15	0.°15	.008269	1.7122	1.7994	1.8019
1 ⅜"	5	1.4935	1.4459	"	"	.010	1.8284	1.8969	1.8997
1 7/16"	5	1.6182	1.5719	"	"	.010	1.9484	2.0219	2.0245
1½"	4½	1.7149	1.6632	"	"	.012343	2.0846	2.1182	2.1168
1 9/16"	4½	1.8393	1.7882	"	"	.012343	2.1816	2.2382	2.2411
1 ⅝"	4½	1.9641	1.9133	"	"	.012343	2.3066	2.3632	2.3647
1 11/16"	4	2.0540	1.9961	"	"	.015625	2.4105	2.4681	2.4695
1 ¾"	4	2.1787	2.1211	"	"	.015625	2.5355	2.5711	2.5742
1 13/16"	4	2.4284	2.3711	"	"	.015625	2.7855	2.8211	2.8240
1"	3½	2.6326	2.5670	0.°20	0.°20	.020392	3.0635	3.1670	3.1704
1 15/16"	3½	2.8823	2.8170	"	"	.020408	3.3135	3.4170	3.4200
2"	3½	3.1041	3.0537	"	"	.020854	3.5666	3.6537	3.6568
2 ⅛"	3	3.2211	3.1446	"	"	.02775	3.7274	3.8448	3.8486
2 ¼"	3	3.5706	3.4945	"	"	.02775	4.0474	4.0948	4.0983
2 5/16"	2½	3.8019	3.7236	"	"	.03324	4.2664	4.3228	4.3264
2 ⅜"	2½	4.0318	3.9459	"	"	.03305	4.3244	4.5500	4.5530
2 7/16"	2½	4.2569	4.1736	"	"	.03825	4.7614	4.7726	4.7767
2½"	2½	4.4848	4.3936	"	"	.040	4.9970	4.9936	4.996
2 9/16"	2½	4.7348	4.6436	"	"	.040	5.2470	5.2436	5.2477
2 ⅝"	2½	4.9574	4.8619	"	"	.04431	5.4810	5.4619	5.4661
2 11/16"	2½	5.2072	5.1119	"	"	.04431	5.7310	5.7119	5.7160
2¾"	2½	5.4371	5.3364	"	"	.049378	5.9.32	5.9364	5.9807

D	n	D_1	D_2	a	β	$(\frac{lead}{2})^2$	x	x_1	x_2
¼"	20	.1653	.1824	0.°04	0.°04	.000635	.3667	.3884	.3846
5/16"	18	.2180	.2163	"	"	.000771	.3944	.3963	.3975
⅜"	16	.2695	.2667	"	"	.0009765	.3808	.3967	.3981
7/16"	14	.3156	.3126	0.°06	0.°06	.001274	.4656	.4936	.4957
½"	13	.3580	.3557	"	"	.001735	.5178	.5357	.5375
9/16"	12	.4076	.4103	"	"	.001735	.5808	.5909	.5936
⅝"	11	.4687	.4676	"	"	.0020657	.6363	.6479	.6492
11/16"	11	.5319	.530	"	"	.0020657	.6967	.7100	.7115
¾"	10	.5789	.5768	0.°10	0.°10	.0025	.8134	.8788	.8784
13/16"	10	.6419	.6398	"	"	.0025	.8759	.9393	.9413
⅞"	9	.6847	.6826	"	"	.003086	.9288	.9936	.9943
15/16"	9	.7470	.7450	"	"	.003086	.9912	1.045	1.0466
1"	8	.7859	.7835	"	"	.003906	1.04175	1.0835	1.0854
1 1/16"	7	.8803	.8776	"	"	.005102	1.1518	1.1776	1.180
1 ⅛"	7	1.0050	1.0026	"	"	.005102	1.2768	1.3026	1.3047
1 3/16"	6	1.0895	1.0863	0.°15	0.°15	.006944	1.4556	1.5363	1.5398
1 ¼"	6	1.2141	1.2118	"	"	.006944	1.5806	1.6613	1.6635
1 5/16"	5	1.2835	1.2796	"	"	.010	1.6768	1.7396	1.7417
1 ⅜"	5	1.4071	1.4036	"	"	.010	1.8018	1.8636	1.8565
1 7/16"	4½	1.4941	1.490	"	"	.012343	1.9075	1.9400	1.9434
1½"	4½	1.6188	1.615	"	"	.012343	2.0325	2.0650	2.0688
1 9/16"	4½	1.7435	1.740	"	"	.012343	2.1575	2.1900	2.193
1 ⅝"	4½	1.8683	1.8651	"	"	.012343	2.2825	2.3150	2.3178
1 11/16"	4	1.9930	1.990	"	"	.012343	2.4075	2.440	2.4426
1 ¾"	4	2.0707	2.067	0.°20	0°.20	.015625	2.5835	2.670	2.6670
1 13/16"	4	2.3203	2.317	"	"	.015625	2.6335	2.917	2.9196
1"	3½	2.5499	2.505	"	"	.020399	3.0535	3.105	3.1065
1 1/16"	3½	2.7587	2.755	"	"	.020399	3.2035	3.355	3.3583
1 ⅛"	3½	2.9711	2.967	"	"	.023654	3.5435	3.567	3.5705
1 3/16"	3	3.1770	3.1727	"	"	.02775	3.7618	3.7727	3.7765
1¼"	3	3.4268	3.4227	"	"	.02775	4.0118	4.0227	4.0268

D	n	D_1	D_2	a	β	$(\frac{lead}{2})^2$	x	x_1	x_2
¼"	20	.1676	.1809	0.°04	.°04381	.000635	.3758	.3965	.3977
5/16"	18	.2428	.2335	"	"	.000771	.4313	.4501	.5514
⅜"	16	.2965	.2749	"	"	0.00976	.3883	.4015	.4029
7/16"	14	.344	.3231	"	"	.001274	.4436	.4497	.4512
½"	13	.3938	.3680	0.°06	.°06480	.001735	.5243	.5345	.5362
9/16"	12	.4576	.4361	"	"	.001735	.5807	.5190	.6204
⅝"	11	.5105	.4794	"	"	.003065	.6373	.6993	.6710
11/16"	11	.5736	.5430	"	"	.003064	.7097	.7819	.7084
¾"	10	.6259	.5899	"	"	.0025	.7649	.7796	.7815
13/16"	10	.6893	.6534	"	"	.0025	.8274	.8433	.8450
⅞"	9	.7340	.6971	"	"	.003086	.8810	.8970	.8986
15/16"	9	.797	.7596	"	"	.003086	.9436	.9496	.9512
1"	8	.8433	.7990	0.°10	.°10899	.003906	1.0583	1.1167	1.1185
1 1/16"	7	.9417	.8963	"	"	.005102	1.169	1.2181	1.2150
1 ⅛"	7	1.0693	1.0113	"	"	.005102	1.294	1.3301	1.340
1 3/16"	6	1.1644	1.1069	"	"	.006944	1.400	1.4380	1.4376
1 ¼"	6	1.2890	1.2323	"	"	.006944	1.525	1.5500	1.5538
1 5/16"	5	1.3736	1.3046	0.°15	.10843	.01	1.7023	1.7796	1.7836
1 ⅜"	5	1.497	1.4299	"	"	.01	1.8273	1.9046	1.9074
1 7/16"	4½	1.5943	1.5193	"	"	.012343	1.9445	1.9941	1.9975
1½"	4½	1.7185	1.6443	"	"	.012343	2.0695	2.1191	2.1231
1 9/16"	4½	1.8437	1.7693	"	"	.012343	2.1843	2.2441	2.2470
1 ⅝"	4	1.9388	1.8498	"	"	.015625	2.3173	2.3946	2.398
1 11/16"	4	2.0585	1.9750	"	"	.015625	2.4123	2.4496	2.458
1 ¾"	4	2.1838	2.100	"	"	.015625	2.5373	2.5746	2.5778
1 13/16"	3½	2.3882	2.2926	0.°20	.21567	.020399	2.837	2.9340	2.9376
1"	3½	2.6397	2.5436	"	"	.020892	3.087	3.1740	3.1778
1 1/16"	3½	2.860	2.7574	"	"	.023654	3.3194	3.3987	3.3994
1 ⅛"	3½	3.1086	3.0074	"	"	.023654	3.5694	3.6567	3.643
1 3/16"	3	3.327	3.2164	"	"	.027755	3.799	3.8477	3.8515
1¼"	3	3.5768	3.4664	"	"	.027755	4.049	4.0977	4.1013
1 5/16"	2½	3.806	3.693	"	"	.030241	4.287	4.3243	4.328
1 ⅜"	2½	4.0567	3.943	"	"	.030241	4.537	4.5743	4.578
1 7/16"	2½	4.2978	4.188	"	"	.033051	4.7746	4.7493	4.7985
1½"	2½	4.5376	4.418	"	"	.033051	5.0245	5.0493	5.0534
1 9/16"	2½	4.7676	4.640	"	"	.036253	5.2807	5.3718	5.375
1 ⅝"	2½	5.0156	4.890	"	"	.036253	5.5107	5.5218	5.5263
1 11/16"	2½	5.2415	5.110	"	"	.040	5.7455	5.7418	5.7460
1¾"	2½	5.4913	5.360	"	"	.040	5.9755	5.9918	5.9944

TABLE CONSTANTS FOR MEASURING U. S. STANDARD, V and WHITWORTH THREADS.

TABLE 10. CONSTANTS USED IN MEASURING EXTERNAL SCREW-THREAD DIAMETERS

SENSITIVENESS OF TOUCH

Minute Variations of Magnitude and Form Detected by the Human Fingers

During the week of the dedication of the exposition buildings, at Chicago, Ambrose Webster and a well known manufacturer of hardened-steel balls were there, and were met one evening at the hotel by the president of the American Machinist Company. The subject of ball bearings was introduced, and the ball manufacturer, taking a hardened and ground ball from his pocket, handed it as a specimen of his work to Mr. Webster, who, rolling it between his fingers, remarked: "Why don't you make them round?" "It is round," was the reply, to which Mr. Webster answered, "No, it is not round—I can feel that it is out of round." The manufacturer was unable to detect any want of truth, and the result was a trifling wager between him and Mr. Webster, who said that if allowed to take the ball home he would measure it, and determine whether or not it was true, and how much it was out, if at all.

A DEMONSTRATION BY AN EXPERT

A few days later Mr. Webster called at this office, armed with a fine micrometer caliper, made by A. J. Wilkinson, of Boston, and said: "I am now prepared to win the wager made in Chicago, as I can demonstrate that the ball is not round. It has around it what may be termed an equatorial line which stands above the surface of the ball, or, in other words, there is a belt extending around it, the diameter of which is greater than that of the ball when measured at any other point than through this belt; and I can pick it out every time by the sense of touch, and place it in the caliper so that it will not pass through, though the caliper be set so that the ball will easily pass through when turned so that this belt or equatorial line does not come into contact with the screw."

This Mr. Webster was successful in doing at every attempt; and Fred J. Miller, then associate editor of the AMERICAN MACHINIST, who was called in to see what he regarded as a remarkably delicate sense of touch, found after a few trials that he could himself easily detect the belt by rolling the ball in his fingers, and demonstrated that he did so by placing it correctly in the calipers at every trial.

ANOTHER EXHIBITION OF SENSITIVENESS

Mr. Webster, again taking the ball and rolling it between his fingers, said there was one feature about it that he had not before noticed, i.e., there seemed to be at a certain point in the belt a slight projection, or, as he described it, a mountain; and after a little examination both he and Mr. Miller demonstrated that they could define the location of this mountain by the sense of touch, and they both placed the ball in the caliper repeatedly so that it just touched, when, if turned very slightly from that position in any direction, it would pass through without touching.

THE ACTUAL VARIATION OF THE BALL

A bench measuring machine in Mr. Webster's shop at Waltham (The American Watch Tool Company), showed that the ball, which was ⅜ inch nominal diameter, actually measured through its smallest diameter 0.37512 inch; through the mean or ordinary diameter of the belt, 0.3752 inch; and through the mountain and belt, or its largest diameter, 0.37539 inch. Thus it is seen that the ordinary diameter through the belt is 0.00008 inch greater than through the smallest part, and that the mountain is 0.00019 inch above the belt, the diameter measured through the mountain being 0.00027 inch greater than the smallest diameter.

CONCLUSION DRAWN FROM THE TESTS

The tests showed, we think conclusively, that a variation in size or shape amounting to less than 0.0001 inch can be detected by the fingers, where, either naturally or by training, the sense of touch or the sense of magnitude is highly developed. So far as the matter has been investigated, it does not seem that such sensitiveness is at all common, very few persons being able to detect any variation or departure from sphericity, or, where they think they do detect it, they fail to prove it by placing the ball in the caliper correctly.

PROFESSOR SWEET'S EXPERIMENT

Shortly after the account of the tests as noted above was brought to the attention of Professor Sweet he wrote us as follows:

Having some friends engaged in the hardened-steel ball business, and being more or less interested in machine-shop measurements, I was naturally interested in your account of Ambrose Webster's thumb and finger caliper, and could only reconcile your statement to my conception of the possibilities by fancying you had one too many ciphers on the account. It takes a fairly good man to detect 0.0001 inch difference in the size of a piece with common calipers, and to concede that a man could do better with his fingers was, at first, straining to one's belief.

Picking up some sample balls at hand, we noted, after but a moment's fingering, that they were not round, and one appeared to have the same peculiarity noted in your account. While we had no means at hand for determining the absolute variation, it was easy with the small measuring machine to determine that the variation was not far from 0.0001 inch.

AIDS IN SETTING CALIPERS TO A STEEL SCALE

Accurate Results Obtained by Simple Appliances

The question as to how close to any given length a machinist ought to set his calipers, using a steel scale, led to quite a discussion in a certain machine shop a year or so ago, and it resulted in the testing of the skill of several lathesmen in this respect. Ten inches was selected to make the setting to, and the calipers were tested with a micrometer. The variation at first was about 0.01 inch, some being plus, others minus.

HOW FINER MEASUREMENTS WERE OBTAINED

Then the caliper points were squared up, making the corners sharp, when much closer measurements were made. Then it was found that by using a scale graduated in hundredths of an inch still greater accuracy was obtained than with coarser graduations; the lines being finer they could be more accurately split. It was also found that it was as easy to set to 10.005 inches as to 10 inches, for on the hundredths graduation the lines and the spaces are about the same width, making it as easy and as accurate to split one as the other. Much closer measurements were made, but the average would not justify one in saying that, with caliper points as generally used, the error would be much less than the breadth of the line on the scale. To set calipers accurately to the work, it is not necessary that the corners of the points be sharp nor parallel to each other, for they are adjusted till a touch is felt, and points slightly rounded are best for this purpose; but rounded points are less accurate for scale work, and also more tedious when inside and outside calipers have to be set to each other.

ADJUSTABLE STOPS AND THEIR USES

In order to make scale measurements exact, with ordinary points, two pairs of adjustable stops were made to fit the scale, as shown in the sketch, Fig. 52. The inside corners of the stops *b b* are cut down flush with the top surface of the scale, and the edge is beveled off one-half the thickness of the line on the scale, as shown in the edge view at *S'*. If a pair of the stops are brought together, their beveled corners form a line the same

breadth as those on the scale, and they can, therefore, be set exactly; then one stop can be slipped away and inside or outside calipers, as the case may be, set to the remaining ones. Lines and spaces are so closely split with these that 10.625 inches can be readily set, and there is not much guess work in setting them to 10.5625 inches on the same graduation.

The outside calipers shown in the sketch were not drawn as they are because it is the easiest way, but because it is believed to be the way they ought to be made. The idea is to make the leg without any useless stock in it. The shape shown does that; they weigh less, take up less room in the tool chest, and are in every way more convenient than when part of the leg is made straight, as they usually are.

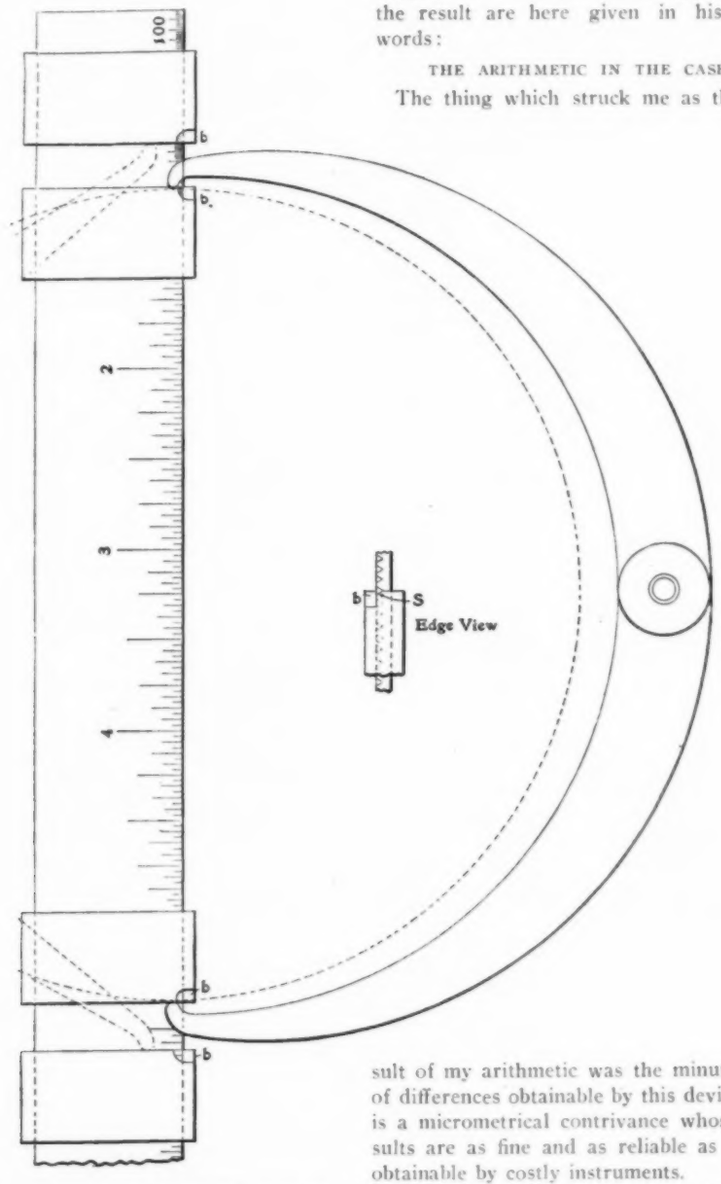


FIG. 52. ADJUSTABLE STOPS FOR SETTING CALIPERS

THE SIDE PLAY OF THE CALIPERS

Making Allowances when Boring Holes for Running, Shrink, and Press Fits

One of the familiar devices of the machinist consists in giving the inside calipers a certain amount of side play, when for any purpose it is desirable to obtain a measure minutely less than the full diameter of the hole, as in making a loose or running fit, such as that of a journal in a solid bearing, or a sliding fit, as of a plunger in a cylinder. The trick is a practically serviceable one, and it occurred to a contributor of ours that it would be well to know the actual differences of dimension which are obtained by different amounts of vibration of the calipers; and so he took the time to do a little figuring for the benefit of readers of the AMERICAN MACHINIST. His method of figuring and the result are here given in his own words:

THE ARITHMETIC IN THE CASE

The thing which struck me as the result of my arithmetic was the minuteness of differences obtainable by this device. It is a micrometrical contrivance whose results are as fine and as reliable as those obtainable by costly instruments.

In Fig. 53, having the circle $A\ B\ D$, with the diameter $E\ D$, we wish to know what will be the length of $A\ D$ or $B\ D$ for different lengths of $A\ B$. I have not found a very quick and easy way to do it, and it may be that there is a considerably shorter cut than mine. Knowing the diameter of the hole $E\ D$, and assuming some definite length for $A\ B$, the total side play of the calipers, we have the length $F\ B$, one-half of $A\ B$, and $C\ B$ or

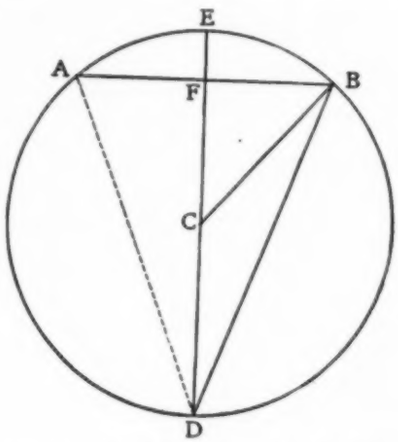


FIG. 53. THE SIDE PLAY OF THE CALIPERS

$C\ D$, one-half of $E\ D$, to find the length of $B\ D$. In the right-angled triangle $F\ B\ C$ we have

$$F\,C = \sqrt{(C\,B)^2 - (F\,B)^2}\,.$$

Then, having the length $F\ C$, and the length $C\ D$ being known, we add them together for the length $F\ D$. Then, with $F\ B$, as before, we have

$$B\,D = \sqrt{(F\,B)^2 + (F\,D)^2}.$$

A PRACTICAL EXAMPLE

We can take a case and work it out by arithmetic. Say that the diameter $E\ D$ is 10 inches and the side play is 1 inch, then $C\ B$ will be 5 inches and $F\ B$ will be 0.5 inch. The length $F\ C$, then will be

$$\sqrt{5^2 - 0.5^2} = \sqrt{25 - 0.25} = \sqrt{24.75} = 4.9749 + .$$

Then for the length $F\ D$, or $F\ C + C\ D$, we have $4.9749 + 5 = 9.9749$, and then

$$B\,D = \sqrt{(F\,B)^2 + (F\,D)^2} = \sqrt{(0.5)^2 + 9.9749^2}$$

$$= \sqrt{0.25 + 99.4986} = \sqrt{99.7486} = 9.9874 \text{ inches}.$$

Here we have in a 10-inch hole with a side play of 1 inch a difference of size of only a little over 0.01 inch, which gives us a little idea of the fineness with which the device will theoretically work. In practice the results are, of course, not so fine, because usually we only guess at the actual amount of the side play, but the guessing of a trained machinist is not far from his actual measuring.

TABULATED RESULTS

I give a little list in Table II of the re-

duced dimensions for different amounts of side play of the calipers in a 12-inch hole. From this, of course, the dimensions may be obtained for holes of other diameters by simple division. Thus, where in the table the side play is 2 inches, if we divide the items by 4 we have the side play and the reduced dimension for a 3-inch hole, or 0.5 inch and 2.9894 inches respectively.

Side play	
0.1	11.9999
0.2	11.9991
0.4	11.9983
0.6	11.9962
0.8	11.9933
1.0	11.9895
1.2	11.9849
1.4	11.9795
1.6	11.9730
1.8	11.9660
2.0	11.9579
2.2	11.9490
2.4	11.9391
2.5	11.9339
3.0	11.9044

TABLE II. REDUCED DIAMETERS INDICATED BY INSIDE CALIPERS FOR DIFFERENT AMOUNTS OF SIDE PLAY IN A 12-INCH HOLE

AXIAL INCLINATION OF THE CALIPERS IN MEASURING FOR SHRINK OR PRESS FITS

In the case worked out above it was desired to produce a hole slightly larger than the piece to go into it, or a

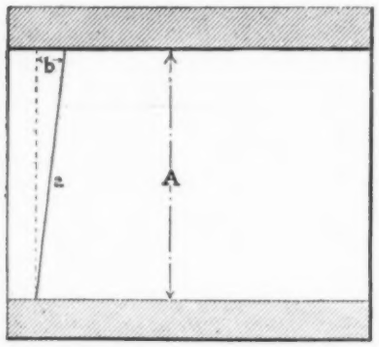


FIG. 54. MEASURING BY INCLINING THE CALIPERS LENGTHWISE OF THE WORK

piece slightly smaller than the hole. In operations where a hole is wanted somewhat smaller than the piece to be shrunk or pressed into it, a similar plan of measuring can be employed, and a table giving the tightness can be computed. The sketch Fig. 54 will serve to make the meaning clear. The distance A is the diameter of a hole and line a is the length of a gage the exact size of the piece to be pressed or shrunk into the hole. The distance b is the amount the gage lacks of assuming a position square or at a right angle to the axis of the hole.

CLOSE WORK POSSIBLE

Very close results can be obtained by this method. A machinist who has used it more or less, recalls once boring holes in a lot of crank webs into which the shafts and the pins were pressed. The pressure determined upon in this case was 40 tons, and none of the fits actually required more than 42 tons, while few, if any, went as low as 38 tons, and it is quite possible that there was difference enough in the metal to cause at least a part of this difference in the force required to press these pieces home.

WORKING OUT THE TABLE

It is an easy matter to make a table as suggested. It is only necessary to find the different lengths for the hypotenuse a for the right-angle triangle of which A is the constant base and b the perpendicular, taking b at different lengths from ⅛ inch to 2 inches. Assuming the diameter to be 12 inches, as in Table 11, then the lengths indicated for different inclinations in the direction of the axis will be as given in Table 12.

Inclination of calipers	
⅛ inch	12.00065
¼ inch	12.00260
⅜ inch	12.00580
½ inch	12.01040
⅝ inch	12.01626
¾ inch	12.02340
⅞ inch	12.03180
1 inch	12.04159
1¼ inches	12.06490
1½ inches	12.09338
1¾ inches	12.12689
2 inches	12.16550

TABLE 12. AXIAL INCLINATION OF CALIPERS IN ALLOWING FOR SHRINK OR FORCE FITS IN A 12-INCH HOLE.

SIDE PLAY OF CALIPERS IN BORING HOLES LARGER THAN A PIECE OF KNOWN DIAMETER

The following is an approximate rule for obtaining the variation in the size of a hole corresponding to a given amount of side play in the calipers. The rule has the merit of extreme simplicity and can be applied equally well to all diameters except the very smallest. In most cases the calculation is so simple that it can be done mentally without having recourse to pencil or paper:

THE CALCULATION

Let

A in Fig. 55 = side play of calipers or end measuring rod *in sixteenths of an inch.*

B = dimensions to which calipers are set, or length of measuring rod *in inches.*

C = difference between diameter of hole and length of B *in thousandths of an inch.*

Then $C = \frac{A^2}{2B}$, within a very small limit.

Example: A standard end measuring rod, 5½ inches long, has ⅜ inch of side play in a hole. What is the size of the hole? In this case $A = 6$ and $B = 5\frac{1}{2}$. Applying the above formula:

$$C = \frac{6 \times 6}{11} = \frac{36}{11} = 3.27 \text{ thousandths}$$

of an inch, or 0.00327 inch. The diameter of the hole, therefore, is $5\frac{1}{2} + 0.00327$ or 5.50327.

THE DEGREE OF ACCURACY ATTAINED

The method will be found to be correct within a limit of about 0.0002 inch if the amount of side play is not more than one-eighth of the diameter of the hole for holes up to 6 inches diameter; within 0.0005 inch for holes from 6 inches up to 12 inches; and within 0.001 for holes from 12 inches up to 24 inches. If the amount of side play allowed be decreased, the accuracy attained is very much greater. To secure the same limit of accuracy with larger holes the amount of side play proportionate to the size of the hole should be decreased. Generally, however, the limits of error allowable are greater in the case of large than of small holes, and the rule may, therefore, be said to hold good for all sizes of holes. For small differences between the length of the measuring rod and the holes, the accuracy of the method is greater the larger the hole. For instance, an allowance of 0.001 inch on a hole 12 inches diameter requires about twice as much side play as in the case of a 6-inch hole.

ALLOWING FOR RUNNING AND DRIVING FITS

This rule has been found to be useful for boring holes of large diameters in which allowances have to be made for running or driving fits, as only a single measuring rod for each nominal size is

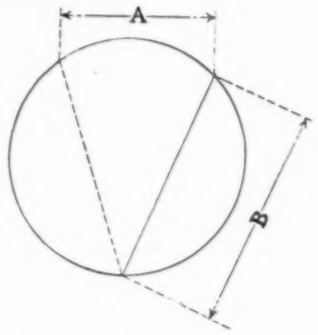


FIG 55. THE SIDE PLAY OF THE CALIPERS

required. The rods should be of standard length, or a known amount less than standard, the allowances being obtained by varying the amount of side play when boring. The rule is also capable of determining limits, as the maximum and minimum amount of side play allowable can be specified. The measuring rods should be tapered at each end and the points slightly rounded. For accurate work, the body of the rod should be encased in some non-conducting material to nullify the effect of the heat of the hand.

THE MATHEMATICS INVOLVED

The geometry involved in this rule at first sight seems rather obscure, and will doubtless form an interesting problem for readers. As a hint toward its solution it may be noted that $32 \times 32 = 1024$, which does not differ by a very large

amount from 1000. The rule is only approximate, and the errors increase with the amount of side play allowed. If used in the manner specified above, however, it is quite sufficiently accurate for most purposes. In internal grinding, when the hole is nearing the required size, an end measuring rod used in this manner forms a very handy method of ascertaining how much metal remains to be removed, and is found to be much quicker than the internal micrometer.

A COMPARISON OF METHODS

In comparing this method with that described in the first section of this article, it should be remembered that the conditions are reversed—that is to say, the first method is for setting calipers to a given dimension *smaller* than a hole of known diameter, whereas the method now described is for boring a hole a given amount *larger* than a gage of known length.

Length of rod, inches	Side play, inches	Diameter of holes, inches: Approximate method	Diameter of holes, inches: Theoretical method
1½	⅛	1.5013	1.5013
1½	3-16	1.5030	1.5029
1½	¼	1.5053	1.5052
2	⅛	2.0010	2.0010
2	3-16	2.0022	2.0022
2	¼	2.0040	2.0040
2	5-16	2.0062	2.0061
3	⅛	3.0006	3.0006
3	¼	3.0026	3.0026
3	⅜	3.00600	3.00588
4	⅛	4.0005	4.0004
4	¼	4.0020	4.0019
4	⅜	4.0045	4.0044
4	½	4.00800	4.00783
6	¼	6.0013	6.0013
6	⅜	6.0030	6.0029
6	½	6.0053	6.0052
6	¾	6.0120	6.0117
9	¼	9.0008	9.0008
9	½	9.0035	9.0034
9	¾	9.0080	9.0078
9	1	9.0142	9.0139
12	⅜	12.0015	12.0014
12	¾	12.0060	12.0058
12	1	12.0106	12.0104
12	1½	12.0240	12.0235
18	½	18.0017	18.0017
18	1	18.0071	18.0069
18	1½	18.0160	18.0156
18	2¼	18.0360	18.0352
24	½	24.0013	24.0013
24	1	24.0053	24.0053
24	2	24.0213	24.0208
24	3	24.0480	24.0470

TABLE 13. SIDE PLAY OF CALIPERS—DIAMETERS OF HOLES AS COMPUTED FOR VARIOUS GAGE LENGTHS AND AMOUNTS OF SIDE PLAY

In measuring the side play it is sufficient to take it to the nearest sixteenth of an inch, and if anything like accuracy is required it should be measured, not guessed at. Table 13 gives the approximate results for a number of sizes, and in parallel columns those obtained by the theoretical method.

SOME MODERN MICROMETER CALIPERS

The engravings Figs. 56 to 61 inclusive show the general appearance of three well known American micrometers and illustrate their distinctive features of construction.

THE BROWN & SHARPE INSTRUMENT

The No. 8 micrometer of this firm is represented by Figs. 56 and 57, the former showing the instrument as fitted with ratchet stop, and the latter a section of the tool without the ratchet. The means of adjustment are plainly shown in the sectional drawing and the details therein represented show clearly the device for clamping the spindle.

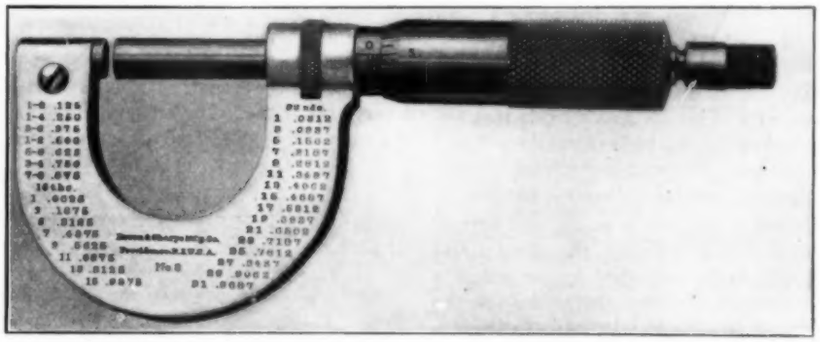


FIG. 56. BROWN & SHARPE 1-INCH MICROMETER

The nurled clamping ring *a* placed, as shown, in a slot milled in the micrometer body, slips over a split ring *b*, which when open is a sliding fit for the spindle and so lengthens the actual bearing for the latter. At one side of the split ring, as will be seen, the metal is cut away, leaving an inclined surface, the pocket formed when the ring is in place in the nurled ring being just deep enough at the bottom to admit a small roller *c*. When ring *a* is moved by the fingers (ring *b* being prevented from turning by means of a lug at one side which enters a slot *d* in the frame *c*) the roller is forced up the inclined surface and the split ring closed on the measuring spindle. With this arrangement the spindle may be clamped fast, or, if desired, the nurled ring may be turned just enough to grip the spindle lightly; whatever tension is put on the split ring is retained until the nurled ring is again operated, as the clamping ring cannot turn even when the spindle is moved.

The ratchet stop as applied to this tool, while not shown in the line engraving, may be explained in a few words. The small nurled extension seen in the halftone is mounted freely on a hub attached to the regular nurled thimble, and has at its inner end a series of ratchet teeth engaging with a spring detent or pawl placed in a pocket of this hub. If more than a certain degree of pressure is exerted in closing the tool on the piece to be measured, the ratchet slips by the pawl and prevents the turning of the spindle, thus all objects measured are subjected to a uniform light pressure. In opening the micrometer the pawl positively engages the ratchet so that it cannot slip.

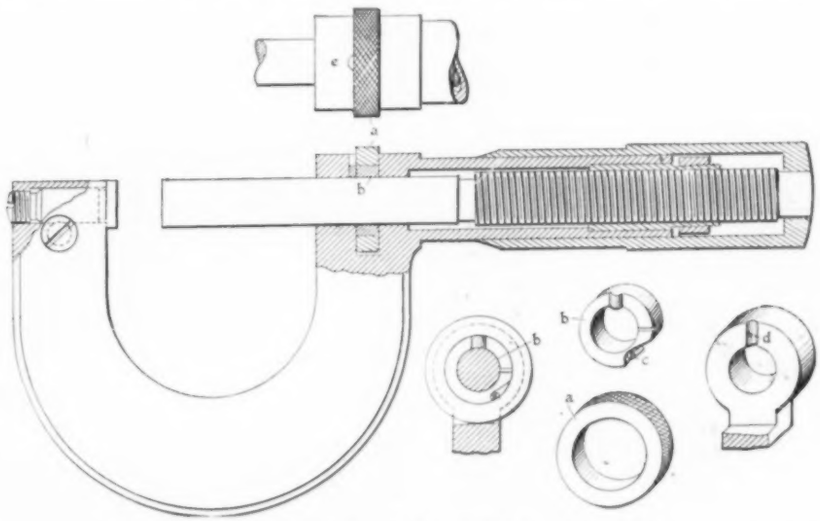


FIG. 57. DETAILS OF BROWN & SHARPE MICROMETER

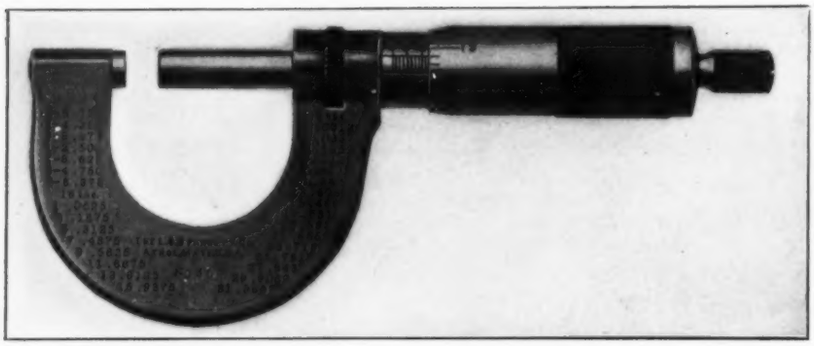


FIG. 58. STARRETT 1-INCH MICROMETER

A STARRETT CALIPER

A micrometer caliper recently brought out by the L. S. Starrett Company is illustrated in Figs. 58 and 59, this tool being known by its makers as their "3-L" micrometer.

The anvil of this instrument is fixed, as indicated in the line drawing, and adjustment for wear between the spindle and the anvil is accomplished by the aid of a thin graduated sleeve *f* placed over the hub *g* of the frame. Instead of the hub itself being graduated, the base or zero line is carried by this sleeve which may be turned by means of a small spanner wrench to bring the zero line around to the required point to compensate for wear. A spring at *h* prevents accidental turning of the sleeve. A nurled locking ring at *i* with the split bushing *j* on the measuring spindle keeps the latter central and by a slight turn locks it firmly. The means of adjustment for wear between the screw and the nut and the arrangement of the "ratchet" stop are both clearly represented in the drawing.

THE SLOCOMB MICROMETER

Figs. 60 and 61 represent one of the styles of micrometers made by the J. T. Slocomb Company. The figures in the tables of decimal equivalents on the body of this instrument, instead of being sunk in, are raised above the surface, as represented in the half-tone, the steel frame being submitted to a pressure, under hydraulic apparatus, of several hundred tons; this not only causes the figures to stand out neatly and clearly, but also, by compressing the metal as it does, forms a very stiff frame. The other features are the same as in other micrometers of the same make except that the thimble having no decimal equivalents upon its face is nurled nearly the full length.

The internal construction is shown in Fig. 61. The adjustment between the measuring screw and its nut is accomplished by drawing the spindle back in line with its axis, thus keeping all the threads in contact. Another important feature is the spring *p* which puts a slight but uniform friction on the spindle, preventing it from becoming loose at any point and also keeping it from turning of its own accord. As the anvil is practically solid with its frame the spindle is arranged to be adjusted to compensate for the wear of the anvil, by turning the main nut *l*. This gives a very fine differential-screw adjustment. The bearing supporting the plain portion of the spindle is a bushing which is easily renewed when worn.

The ratchet stop with which the micrometer in Fig. 60 is provided contains two hardened balls and a spring so arranged that the pressure against the outer shell is balanced. The ball ratchet drives positively when opening the micrometer but when turned forward slips upon a certain pressure being applied.

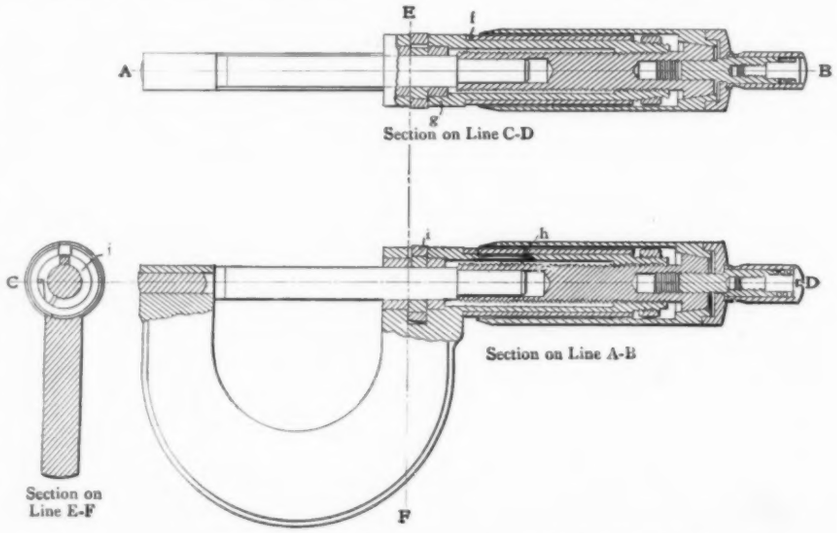


FIG. 59. SHOWING CONSTRUCTION OF STARRETT MICROMETER

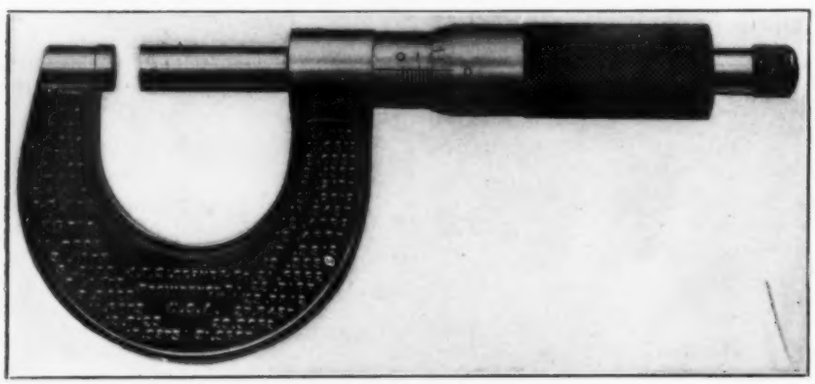


FIG. 60. SLOCOMB 1-INCH MICROMETER

THE MASSACHUSETTS TOOL COMPANY'S MICROMETER

This instrument, in the one-inch size, has a drop-forged frame stamped with decimal equivalents and fitted with a neat eccentric-locking device for the spindle. The thimble by which the spindle is rotated is graduated to read directly to half thousandths. Compensation for wear between spindle end and anvil is made by adjusting the latter in its seat in the frame. One style is made with a round-end thimble to facilitate handling and another one-inch design has a flat base and a hollow anvil through which a steel plug is passed, converting it into a micrometer depth gage.

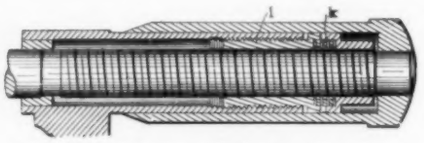


FIG. 61. HEAD OF SLOCOMB MICROMETER

Obituary

H. C. Hoefinghoff, president of the Bickford Drill and Tool Company, Cincinnati, died March 2.

Business Items

The New England office of the Link-Belt Company has been moved to 84 State street, Boston, Mass.

Robert J. Emory & Company, builders of special machinery, have moved into their plant, corner Sherman avenue and Runyon street, Newark, N. J.

W S. Barstow & Company, of New York and Portland, Ore., have opened a Montreal office in the Bank of Ottawa building, which will be in charge of Robert S. Stangland.

The Royal Motor Car Company, of Cleveland, Ohio, are providing for a power plant, in addition to the other buildings, to serve their new factory. Dodge & Day, of Philadelphia, are acting as advisory engineers.

The January shipments of the Wilmarth & Morman Company, Grand Rapids, Mich., makers of drill grinders and loose pulleys, exceeded in amount that of any one month, with one exception, during the past six years.

The Fulton Machine and Vise Company, Lowville, N. Y., report a constantly increasing demand for their vises, and have requested their customers to place their orders as far in advance as possible to avoid being inconvenienced.

The Consolidated Press and Tool Company, lately of 100 No. Clinton St., Chicago, has moved to Hastings, Mich. L. F. Carlton, who has been with the company for several years past, will represent them in Chicago, at 14 South Canal Street.

The Pittsburg Automatic Vise and Tool Company, Pittsburg, Penn., has just been allotted the contract from the United States Government for vises to be shipped to Panama. This is one of the many orders filled by the company for Government delivery.

Edgar T. Ward & Sons, 23 Purchase street, Boston, Mass., have been appointed eastern distributors for the Seamless Tube Company of America, of Monesson, Pa., with G. A. Hastings, formerly manager of the tubing department of the Brown & Wales Company, in direct charge.

The American Blower Company, Detroit, Mich., report an exceptionally large growth in their business. An addition to their steel plate fan shop is nearly completed and the company's architects are at work on an addition to their power plant and engine construction department.

The Carnegie Steel Company has awarded contracts to the Buffalo (N. Y.) Forge Company for gas scrubbing fans for the Edgar Thomson furnaces, Carrie furnaces, and the Youngstown, O., plant. These are specially designed fans for removing the dust from blast furnace gases preliminary to their use in gas engines.

The Jacobson Machine Manufacturing Company, Warren, Penn., has made arrangements with the Rock Isand Tool Company, which has just been incorporated at Rock Island, Ill., providing for the transfer of the Jacobson Company's vise business. The Jacobson Company retains a considerable interest in the new concern.

Henry J. Hauser, formerly foreman of the tool room of the Eastman Kodak Company, Carl A. Weidner, master mechanic of Yawman & Erbe Manufacturing Company for eight years, and John C. Eiseman have formed a partnership for the manufacture of special machinery and tools. The address is Hauser, Weidner & Company, 222 Mill street, Rochester, N. Y.

The Hisey-Wolf Machine Company, Cincinnati, Ohio, manufacturers of portable electrical drills and grinders, has increased its capital stock to $100,000. The increase is to provide additional facilities to handle their rapidly growing business. This company enlarged its present factory about two years ago, but has again outgrown it and will build an up-to-date plant, giving employment to about two hundred people.

The Smith Countershaft Company, Boston, Mass., state that their single belt reversing and other countershafts are growing in demand so rapidly that their business has been twice as large the past twelve months, as it was the preceding twelve months. A number of plants are using their countershafts almost entirely and the Jefferson Manufacturing Company, Lexington, Mass., have just ordered fifty and are going to equip their plant throughout with the Smith countershafts.

Trade Catalogs

Norton Grinding Co., Worcester, Mass. Pamphlet describing Alundum. 12 pages, 3½x6 inches, paper.

S. A. Woods Machine Company, Boston, Mass. Specification sheet of No. 226 knife grinder. Illustrated.

G. M. Yost Manufacturing Company, Mechanicsburg, Penn. Folder illustrating and describing Stephens and Snediker vises.

Ransom Manufacturing Company, Oshkosh, Wis. Catalog of motor-driven grinders. Illustrated, 18 pages, 6x9 inches, paper.

Crocker-Wheeler Company, Ampere, N. J. Bulletin No. 74, illustrating and describing engine type alternating current generators.

American Blower Company, Detroit, Mich. Catalog No. 206, describing vertical self-oiling steam engines. Illustrated, 60 pages, 7x9 inches, paper.

The Goldschmidt Thermit Co., 43-49 Exchange Place, New York. Pamphlet describing process of rail welding. Illustrated, 4x9 inches, paper.

The M. W. Kellogg Co., 143 Liberty St., New York. Pamphlet entitled "Some Stacks" illustrating chimneys built of corrugated perforated radial brick.

Miller Saw-Trimmer Company, Milwaukee, Wis. Catalog describing Miller universal gage, saw and trimmer. Illustrated, 12 pages, 8x10½ inches, paper.

Wendell & MacDuffie, 26 Cortlandt St., New York. Catalog No. 16, describing asbestos and cement fire-proof materials. Illustrated, 23 pages, 4x9 inches, paper.

Ingersoll-Rand Co., 11 Broadway, New York. Pamphlet Form 410, entitled "Some Economical Applications of Compressed Air in the Cotton Industries." Illustrated.

Chicago Pneumatic Tool Co., Chicago, Ill. Catalog No. 21, covering line of electric drills, grinders, drilling stands, magnetic old-man hoists, etc. Illustrated, 60 pages, 6x9 inches, paper.

Goodell-Pratt Co., Greenfield, Mass. Catalog, No. 8, describing complete line of tools made by this company, including over fifty new ones. Illustrated, 208 pages, 6x9 inches, paper.

The Simplex Manufacturing Company, 140 Nassau street, New York. Catalog describing the Simplex combination bench-filer and hack-saw. Illustrated, 5x7½ inches, 23 pages, paper.

Deutsche Telephonwerke, G M. B. H., Berlin, Germany. Catalog in English of telephone apparatus, machine tools, twist drills and projectile parts. Illustrated, 84 pages, 9x10 inches, paper.

Emerson Electric Manufacturing Company, St. Louis, Mo. Bulletin No. 3304, illustrating and describing electric forge blowers. Bulletin No. 3503 illustrating and describing electric exhaust fans.

Charles Engelhard, 41 Cortlandt St., New York. Catalog describing Heraeus "Le Chatelier" pyrometer with letters of recommendation from users. Illustrated, 6x9 inches, 55 pages, paper.

C. Drucklieb, 132 Reade St., New York. Booklet, "Railroad Sandcraft," which refers to the use of the injector sand blast apparatus for cleaning steel cars, bridges, etc. Illustrated, 20 pages, 4½x6 inches, paper.

Manufacturers

The Illinois Molding Company, Chicago, Ill., will erect a new plant.

The Ashland (Wis.) Iron and Steel Company is extending its plant.

The Lynn (Mass.) Gas and Electric Company will double its capacity.

Roberts & Oake, Sioux City, Iowa, will erect a $150,000 packing plant.

Fay & Scott, Dexter, Me., machinery builders, will enlarge their plant.

The David Maydole Hammer Company, Norwich, N. Y., will enlarge its plant.

The Missoula (Mont.) Gas Company has purchased a site for its new gas plant.

The Ohnstrand Metal Furniture Company, Jamestown, N. Y., will erect a new plant.

The Hilles & Jones Company, Wilmington, Del., will erect a new $35,500 machine shop.

The Ajax Forge Company, Chicago, Ill., has had plans prepared for a $25,000 factory.

The Electric Cable Company, Bridgeport, Conn., will double the capacity of its plant.

The Gardner (Mass.) Machine Works has awarded contract for an addition to its plant.

The Delaware & Hudson Railroad Company will erect a power plant near Mechanicsville, N. Y.

The Wright Wire Company will build a two-story addition to its plant at Palmer, Mass.

The plant of the Smythe File Company, Albany, N. Y., recently gutted by fire, will be rebuilt.

The Minneapolis (Minn.) Steel and Machinery Company will erect additions to cost $30,000.

The Lansing (Mich.) Fuel and Gas Company is erecting a new gas plant to cost $200,000.

The Standard Welding Company, Cleveland, Ohio, is having plans prepared for a new plant.

The Sioux City (Iowa) Foundry and Manufacturing Company, is about to begin on its new plant.

W. F. & John Barnes Company, Rockford, Ill., machine tool manufacturers, will build an addition.

The Traut & Hine Manufacturing Company, New Britain, Conn., will build a new power house.

The Roanoke (Va.) Raiway and Electric Company will erect a new power plant to cost $225,000.

The Abendroth & Root Mfg. Company, Newburgh, N. Y., manufacturing boilers, etc., is building an addition.

The plant of the Federal Railway Signal Company, at Troy, N. Y., which recently burned, will be rebuilt.

The Rockford (Ill.) Lathe and Tool Works is being incorporated. Plans for a plant have been drawn. Edwin Strickland, formerly of Cincinnati, is interested.

The Mutual Benefit Ice Company, Newark, N. J., has been incorporated. A plant for the manufacture of ice will be erected. August N. Joeck, Ott Jahn, etc., incorporators.

Pawling & Harnischfeger, crane manufacturers, Milwaukee, Wis., will build an extension to the electric and machine departments and assembling and erecting floor.

The Lubecker Maschinenbau Aktien Gesellschaft, Lubeck, Germany, has rented a large tract of land for the purpose of enlarging its plant for building dredging machinery, etc.

The Hall Signal Company is considering a plan for making extensive improvements to the plant in Garwood, N. J., which will require an expenditure of almost $1,000,000.

The Cook Construction Company, Des Moines, Iowa, is contemplating the erection of a factory for the manufacture of a ditching machine invented by William F. Cook.

It is reported that H. W. Goddard, president of the Spencer Wire Company, Worcester, Mass., is at the head of a scheme to construct a steel wire mill to cost over $2,000,000.

The American Telegraphone Company, Wheeling, W. Va., is in the market for complete equipment for the manufacture of work which will be similar to typewriters or sewing machines.

The Colorado City Stove and Furnace Company, Colorado Springs, Colo., recently organized, has purchased site for its foundry. C W Cunningham, of Newark, Ohio, is general manager.

Contract has been awarded for the erection of a factory building and power house for the American Axe and Tool Company, at East Douglas, Mass., to replace the buildings recently burned.

The Smoke Consumer, Heater and Ventilator Company of Des Moines, Iowa, a new concern capitalized at $75,000, is having plans prepared for a factory to cost $50,000. W. N. Simmons is president.

The Moore-Hopkins Manufacturing Company, of St. Louis, Mo., has been reorganized as the Moore-Hopkins Billing Machine Company, with a capital of $2,500,000. A new plant to employ 1000 people will be built.

The Guanajuato Power and Electric Company, of Colorado Springs, Colo., operating a $1,500,000 power plant in the Mexico mining district will erect a similar plant on the Rio Angulo in the state of Michoacan, Mexico.

The Johnson Manufacturing Company, New Haven, Conn., has been incorporated. The concern is to manufacture hardware novelties and the incorporators are J. Willis Downes, H. W. Bradley and A. W. Johnson, of New Haven.

The Samuel C. Tatum Company, Cincinnati, Ohio, is contemplating the erection of a large new four-story factory building; also a foundry building 110x300 feet, with power plant, etc., to properly care for large increase in their business, their specialties being iron castings, copying presses, stationers' hardware, binders' and printers' machinery. Catalogs and information on equipment, etc., bearing on this matter will be appreciated by the company.

Miscellaneous Wants

Advertisements will be inserted under this head at 25 cents a line each insertion. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded.

Cox Computers, 75 Broad St., New York.

Caliper cat. free. E.G.Smith Co.,Columbia,Pa.

Universal Test Indicator circulars free. H. A. Lowe, Lock Box 146, Cleveland, O.

Light fine machry. to order; models and elec. work specialty. E. O. Chase, Newark, N. J.

Will buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Electrical apparatus designed and built. Geo. M. Mayer, M. E., 1131 Monadnock Block, Chicago, Ill.

Gas engines designed to order. Marine and automobile work a specialty. H. L. Towle, 150 Nassau street, New York.

Special machinery accurately built. Screw machine and turret-lathe work solicited. Robt. J. Emory & Co., Newark, N. J.

Special machinery to order. Catalog of small engines and boilers and engine castings 10c. Sipp Elec. & Mach. Co., Paterson, N. J.

Wanted, at once—Two Brown & Sharpe No. 00 hand milling machines; good prices if machines are in good condition. Address A. H. Fox Gun Co., Philadelphia, Pa.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

Patent attorney, experienced and successful, with good engineering record, would like to hear from parties requiring whole or part time. Box 704, AMERICAN MACHINIST.

Advice — Mechanical, both practical and technical. Tell me your needs. I'll tell you the cost. Results or no fee. Jos. V. Woodworth, M. E., Arbuckle building, Brooklyn, N. Y., U. S. A.

A large English firm of machine-tool importers, having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Isaac B. Owens, patent attorney, 100 Broadway, New York City, specialist in oil and gas engines, automobiles and automatic machinery. Patent applications entrusted to me will receive careful, personal attention, and patents secured which will protect.

Successful draftsmen drawing $125 to $200 monthly require thorough drafting room knowledge. As chief draftsman of engineering firm I know exactly the quality and quantity of experience and practical training you must have, and prepare you by mail, home instructions for above paying positions, which I furnish free anywhere. Complete highest grade drawing outfit, with German silver set of tools, value $13.85, free. Address Chief Draftsman, Div. 4, Eng.'s Equip't Co., (Inc.), Chicago.

Business Opportunities

Wanted—Orders for duplicate work from the bar. It will pay you to see what we can do for you. J. S. Jackson & Son, Bath, Me.

Wanted—To meet a person or persons having either a secret or patented process, chemical or mechanical, for making steel suitable for armor plate. Good opportunity for right party. Address Box 710, AMER. MACHINIST.

Wanted—A position in some reliable manufacturing business by man of 35, having engineering training and experience, with the idea of investing money in the business. Eastern location preferred. P. O. Box 412, Cincinnati, Ohio.

Wanted—Party in Canada and England to manufacture and market thread-milling machine invented by me. This machine can be attached to any engine lathe and will revolutionize thread cutting. Address Paul Krastin, 4550 Uber street, Philadelphia, Pa., U. S. A.

We can build machinery for quick delivery. A shop building machine tools wishes to take contracts for the construction of machinery or anything that can be produced in a foundry and machine shop. Send drawings and specifications and estimates will be made with guarantee of quick delivery. We can refer to a standard line of tools now on the market as to the quality of workmanship. Box 75, AMERICAN MACHINIST.

Wanted—A good superintendent capable of handling pattern shop, foundry and machine shop departments in a general jobbing, repairing and manufacturing shop located in a rapidly growing city of two hundred thousand inhabitants, center of a big lumbering country in the West; one who could invest about $10,000 preferred, an excellent opening for the right man. Full investigation demanded and given. Address Box 692, AMER. MACH.

For Sale

For Sale—Foundry, wood and iron machine shop. Box 74, Albion, N. Y.

For Sale—The leading jobbing pattern shop of Colorado. Address J. L. Gard, Denver.

For Sale—One second-hand 800-lb. single frame Morgan steam hammer. Box 660, AM. M.

For Sale—Jobbing iron and brass foundry, located in western Pennsylvania; price $6000. Address Box 708, AMERICAN MACHINIST.

For Sale—Cyclopedia of modern shop practice, four volumes; bound in green morocco leather. Practically new; cost $18; will sell for $6. Address L. N. O., Box 425, Chicago, Ill.

For Sale—Plant suitable for machine shop and foundry. Splendid location, New York State. Good shipping point. Would take part interest in good manufacturing enterprise. E. W. Futton, Lowville, N. Y.

For Sale—One 8x8 vertical two-cylinder Curtis air compressor in working order; also one Sprague 15-h.p. 500-volt motor, 1100 revolutions, new. Standard Motor Construction Co., 172 Whiton St., Jersey City, N. J.

For Sale—Lease and complete power and transmission equipment, including boiler, engine, pulleys, shafting, hangers, etc. Building 100x100 feet, 3 stories. Pittsburgh Gage & Supply Co., 31st St. and Liberty avenue, Pittsburg, Pa.

Wants

Situations and help advertisements only inserted under this head. Rate 25 cents a line for each insertion. About six words make a line. No advertisements under two lines accepted, and no advertisements abbreviated. The cash and copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide situation want or help want advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Designer, graduate of university, with six years' practical shop and drawing room experience in machine tools and jigs desires position preferably as assistant superintendent. Box 722, AMERICAN MACHINIST.

MASSACHUSETTS

Expert grinder, surface and universal, wishes position on work requiring special accuracy. Emery, 19 Fruit St., Worcester, Mass.

A young man desires a position as a designer on jigs and tools; prefers cotton machinery; over 10 years' shop experience; considerable inventive ability; temperate. Address "Machinist," Box 711, AMER. MACH.

NEW JERSEY

Cost accountant desires to locate with manufacturing firm; thoroughly practical and capable of installing up-to-date methods. Box 707, AMERICAN MACHINIST.

NEW YORK

Draftsman of experience seeks position. Box 694, AMERICAN MACHINIST.

Lathe hand wishes to change position; 7 years' experience on fine work. Address Box 712, AMERICAN MACHINIST.

Experienced mechanical draftsman desires position in New York City or neighborhood. Box 709, AMERICAN MACHINIST.

Millwright foreman wishes position; eight years in present place; references. Address Box 713, AMERICAN MACHINIST.

Draftsman—Experienced machine designer desires engagement, New York or New Jersey preferred. Box 652, AMERICAN MACHINIST.

Expert in patent drafting and developing desires a few more clients; intricate machinery specialty; A-1 work for A-1 price; secrecy guaranteed. Box 606, AMERICAN MACHINIST.

Position as superintendent of machine shops; accurate, interchangeable commercial work; married man with first-class reference; character and ability open. Address Box 689, AMERICAN MACHINIST.

Experienced superintendent or purchasing agent desires change; high grade interchangeable work, methodical increase in production; appliances improved; costs reduced. Box 695, AMERICAN MACHINIST.

Foreman; age 29; strictly first-class machinist, toolmaker, all kinds of work, good in developing inventions, drawings; 15 years' experience; wants position; highest references. Box 677, AMERICAN MACHINIST.

Works manager or superintendent; business, technical and mechanical training; familiar with manufacturing methods; several

years' experience as executive; location, unimportant. Box 723, AMERICAN MACHINIST.

Position as manager of works; held similar position seven years; can improve and design machinery; good mechanical, executive and business abilities; furnish best of references from concern where now employed. Box 374, AMERICAN MACHINIST.

Iron foundry superintendent or foreman is open to immediate engagement; loam, dry and green sand; capable of handling large force; well up in cupola practice, mixing by analysis, heavy and light machinery; temperate, economical; first-class references. Address Box 719, AMERICAN MACHINIST.

OHIO

A-1 mechanical draftsman wishes to obtain a position some place west; best education and four years' experience. Box 716, AMERICAN MACHINIST.

PENNSYLVANIA

As assistant superintendent with firm manufacturing forgings, drop forgings, etc. Technical graduate; (27); 6 years' practical experience; well posted modern cost keeping system, design of dies, tools, etc. Plant, Chicago district preferred. Box 720, AM. M.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Wanted—First-class operator on Jones & Lamson turret lathe; also one first-class all-around machinist. The New Machine Co., Danbury, Conn.

ILLINOIS

Wanted—Several first-class vise and floor men accustomed to heavy machine tool work; steady employment and good wages. Box 685, AMERICAN MACHINIST.

Wanted—Working foreman to handle ten to twenty men on erecting heavy machine tools; good wages for right party; married man preferred. Box 684, AMERICAN MACHINIST.

Representative wanted in New York City—Man to handle, on commission basis, sheet metal line; have already an established business, but desire to increase it; can be handled satisfactorily by live manufacturer's agent. Address Box 717, AMERICAN MACHINIST.

Wanted, mechanical draftsman—An excellent opportunity for a young man with technical education, experienced in the design and use of jigs and fixtures for the production of small, interchangeable parts; only men with first-class records and references will be considered; to the right man we will offer a position in charge of our drafting room, with excellent opportunity for advancement; factory modern and progressive; give experience in detail, salary required, and references; correspondence will be considered confidential and returned if desired. Box 718, AM. MACH.

INDIANA

Wanted—Ten good lathe men; increasing force; good wages; steady employment. Western Motor Co., Logansport, Ind.

IOWA

Wanted—Three or four first-class floor or lathe hands; steady employment assured. Address Ottumwa Iron Works, Ottumwa, Ia.

Wanted—First-class patternmaker of experience in mining machinery, Corliss and slide-valve engine work. Address Ottumwa Iron Works, Ottumwa, Iowa.

MARYLAND

Wanted—Draftsmen, experienced in dredging and pumping machinery, with thorough knowledge of practical designing and detailing; first-class salary to first-class men; state full particulars regarding age, education, experience and salary desired; communications confidential. Address Box 680, AMER. MACH.

MASSACHUSETTS

Wanted — Experienced draftsmen on tool design, shop equipment, structural work, valve design, and miscellaneous; also tracers. Apply by letter to Walworth Mfg. Co., South Boston, Mass.

MICHIGAN

Wanted—First-class man for superintendent of up-to-date automobile factory; capacity, 1200 cars; give reference. Box 721, AMERICAN MACHINIST.

Assistant foreman for machine shop in a growing, well-established business, employing 100 men; excellent opportunity for advancement; must be capable of handling men to best advantage with up-to-date methods, also thoroughly understand jig, tool, and lathe work for light, high-grade machinery. State wages, references, ability, etc. Box 656, AMERICAN MACHINIST.

MISSOURI

Wanted—First-class adjusters accustomed to adding machine and typewriter work. Universal Adding Machine Co., St. Louis.

Wanted—First-class machinists, bench men and assemblers; none other need apply but those who have had experience in automobile work. Address Kansas City Motor Car Co., Sheffield Station, Kansas City, Mo.

Wanted — First-class blacksmith to take charge of blacksmith department of five fires; one who has had experience with hammer work, exact forgings, and accustomed to very fine work. Box 663, AMER. MACHINIST.

NEW JERSEY

Wanted — Experienced men for installing marine gasolene engines; steady employment. Apply at once, Standard Motor Construction Co., 172 Whiton St., Jersey City, N. J.

Wanted—Salesmen to take new tool as side line; good seller; liberal commission. State experience, territory now working in, and lines carried. Address Box 367, Newark, N.J.

Wanted—Machine designer; technical and practical. Capable of directing five or six draftsmen; permanent position to acceptable party; state age, experience and salary expected. "M. D. X.," AMERICAN MACHINIST.

Wanted—Tool, die and instrument makers accustomed to accurate, complicated work; steady work and good wages to thoroughly competent men; give references. Address Box 438, AMERICAN MACHINIST.

We are increasing our tool-making department and solicit applications from toolmakers and machinists who are experienced on fine and complicated work. Apply to Victor Talking Machine Co., Camden, N. J.

We have increased our plant and desire floor and vise hands for day work and lathe hands for night work. Good pay and steady work for good men. Address or apply at Pond Machine Tool Co., Plainfield, N. J.

NEW YORK

Wanted—First-class Landis grinder hand. Box 715, AMERICAN MACHINIST.

Wanted—First-class machinist for laying out forged crank shafts, etc. Box 714, AM. M.

Wanted—Experienced draftsmen, toolmakers and machinists; give age, references and wages expected. Remington Arms Co., Ilion, N. Y.

Wanted—Architectural draftsman, with experience in building construction and mechanical drafting; location, New York City; state age, experience and salary expected. Box 762, AMERICAN MACHINIST.

Wanted—Several first-class mechanical and electrical draftsmen. Apply, giving age, experience and salary expected to Engineer in Charge, Drafting Department, General Electric Company, Schenectady, N. Y.

Wanted—First-class man thoroughly familiar with all kinds of tool work, one capable of handling help and filling position of responsibility. State age, experience and salary expected. Box 725, AMER. MACHINIST.

Wanted—First-class tool, jig and fixture designer, who can design appliances for facilitating the construction and the assembling of automobiles, and at the same time maintain a high degree of accuracy and first-class workmanship. Address Box 724, AM. M.

Casualty company invites applications from competent mechanics experienced in boiler and elevator work for the position of field inspector; and from engineers having in addition an intimate knowledge of general factory equipment and operation, for the position of chief inspector. Address "Casualty," care AMERICAN MACHINIST.

OHIO

Wanted—An A-1 man to sell presses and forging machinery. Box 703, AMER. MACH.

Wanted—Detailers and designers on heavy machine tool work. Address Niles Tool Works Co., Hamilton, Ohio.

Wanted — First-class structural engineer capable of designing steel buildings, bridges, etc.; state age, qualifications, initial salary expected, etc. Address 567, AMER. MACH.

Wanted—Superintendent and detail draftsmen for shop manufacturing mine equipment, including steam and electric hoists, cages, tipple equipment, mine cars, etc. Box 701, AMERICAN MACHINIST.

Help Wanted—Mechanic thoroughly up in pressed steel stampings of special shapes and forms, hot work, largely 8 to 20 gage, the party must be thoroughly familiar with machinery, presses, steam and Bradley hammers, bulldozers, the designing and making of special dies and tools for such work. In reply state fully age, references, former occupation, and compensation expected. Address 698, AMERICAN MACHINIST.

PENNSYLVANIA

Wanted—First-class jig and fixture makers for fine, light work. Demorest Manufacturing Co., Williamsport, Pa.

Wanted—First-class floor hands and fitters for machine-tool work. Colburn Machine Tool Company, Franklin, Pa.

Wanted — Capable diemakers to work on heavy drop-forge dies; steady work for the proper applicants. Apply, giving references, as well as wages expected, Box 705, AM. M.

Wanted — First-class die makers on fine dies at once. Good, clean, light shop, and best wages to right men. The Adder Machine Company, Wilkes-Barre, Pa.

Wanted—Mechanical superintendent familiar with high-speed engines and boiler construction, as well as modern shop practice. Machine shop, foundry and boiler shop, employing about 200 hands. Address Box 706, AMERICAN MACHINIST.

Wanted—A first-class foundry foreman for iron foundry employing several hundred men on heavy and medium work; must be a practical energetic man, capable of organizing and handling a foundry in all its details; only men holding similar positions need apply. State experience, age, nationality and present salary. Address Box 678, AMER. MACHINIST.

RHODE ISLAND

We are continually adding to our force, experienced toolmakers, machinists and draftsmen on special tools, fixtures and models for light, high-grade machinery. Good wages and steady employment. Apply to Taft-Peirce Mfg. Co., Woonsocket, R. I.

VERMONT

Wanted—Foreman for erecting department in shop building machine tools; state experience and give references; good opening for the right man. Box 638, AMER. MACHINIST.

WISCONSIN

To cope with the continuous enlargement of our business, first-class machinists, patternmakers, molders and boilermakers can find steady employment. Box 899, Milwaukee.

Large concern building excavating and railway machinery wants to correspond with first-class mechanical draftsmen with view to filling future vacancies as they occur; wants men now employed; give full experience and reasons for changing; shop experience great advantage; all letters acknowledged and held confidential. Box 919, AMERICAN MACHINIST.

FOREIGN

We have increased our plant and will shortly require a large number of first-class men, as floor and vise hands, lathe hands, boilermakers and molders. We employ at present about 800 men, manufacturing locomotives and railroad cars, gas engines and steam engines. Good opportunity for the right men to return to the "old country" and build their own home. Lots to be had very cheap in beautiful surroundings, close to the shop. Good wages. Address or apply to Vagn- och Maskinfabriks Aktiebolaget, Falun, Sweden.

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Aftercoolers, Air
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Arbor Presses
Barnes Co., W. F. & John, Rockford, Ill.
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Niles-Bement-Pond Co., New York.
Wilmarth & Morman Co., Grand Rapids, Mich.

Arbors
Butterfield Co., Derby Line, Vt.
Cochrane-Bly Co., Rochester, N.Y.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
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Architects
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Barrels, Steel
Lyon Metallic Mfg. Co., Aurora, Ill.

Barrels, Tumbling
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Globe Machine & Stamping Co., Cleveland, Ohio.
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Underwood & Co., H. B., Philadelphia, Pa.

Bearings, Ball and Roller
Boston Gear Works, Norfolk Downs, Mass.
Hess-Bright Mfg. Co., Phila., Pa.
Hyatt Roller Bearing Co., Harrison, N. J.
Pressed Steel Mfg. Co., Phila., Pa.
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Belt Dressing
Cling-Surface Mfg. Co., Buffalo, N. Y.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Rhoads & Sons, J. E., Phila., Pa.
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Belt Filler
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Belt Lacing Machine
Birdsboro Steel Foundry & Mach. Co., Birdsboro, Pa.

Belting, Leather
Main Belting Co., Phila., Pa.
Rhoads & Sons, J. E., Phila., Pa.
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Whitman & Barnes Mfg. Co., Chicago, Ill.

Bending Machines, Hydraulic
Niles-Bement-Pond Co., New York.
Watson-Stillman Co., New York.

Bending Machinery, Plate
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Niles-Bement-Pond Co., New York.
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Sellers & Co., Inc., Wm., Philadelphia, Pa.
Toledo Machine & Tool Co., Toledo, Ohio.
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Bending Machines, Power
American Road Machine Co., Kennett Square, Pa.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
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Bethlehem Foundry & Mach. Co., South Bethlehem, Pa.
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Long & Allstatter Co., Hamilton, Ohio.
National Machinery Co., Tiffin, O.
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Swaine Co., Fred J., St. Louis, Mo.

Bending Tools, Hand
American Road Machine Co., Kennett Square, Pa.
Estep & Dolan, Sandwich, Ill.
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Blanks, Nut and Screw
Dyson & Sons, Jos., Cleveland, O.
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American Blower Co., Detroit, Mich.
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Prentiss Tool & Supply Co., New York.
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Keuffel & Esser Co., New York.
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Keuffel & Esser Co., New York.

Boilers
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Niles-Bement-Pond Co., New York.
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Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Machinery Co., Bowling Green, Ohio.
Standard Engineering Works, Ellwood City, Pa.
Vandyck Churchill Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.
Wells Bros. Co., Greenfield, Mass.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Bolt Heads
Lang Co., G. R., Meadville, Pa.

Bolts, Coupling
Cleveland Cap Screw Co., Cleveland, Ohio.
National-Acme Mfg. Co., Cleveland, O.

Bone for Case Hardening
Rogers & Hubbard Co., Middletown, Conn.

Books, Mechanical
American School of Correspondence, Chicago, Ill.
Henley Pub. Co., N. W., New York.
Hill Publishing Co., New York.
Piers, Frank, Philadelphia, Pa.
Sames, C. M., Jersey City, N. J.

Boosters
Burke Electric Co. Erie, Pa.
C & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
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Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Boring and Drilling Machines, Horizontal
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Betts Mach. Co., Wilmington, Del.
Binsse Mach. Co., Newark, N. J.
Boynton & Plummer, Worcester, Mass.
Detrick & Harvey Mach. Co., Baltimore, Md.
Fitchburg Machine Works, Fitchburg, Mass.
Fosdick Mach. Tool Co., Cin., O.
Gisholt Mach. Co., Madison, Wis.
Hill, Clarke & Co., Inc., Boston, Mass.
Kern Machine Tool Co., Cincinnati, Ohio.
Lucas Mach. Tool Co., Cleveland, Ohio.
McCabe, J. J., New York.
Motch & Merryweather Machinery Co., Cleveland, O.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Pawling & Harnischfeger, Milwaukee, Wis.

Boring and Drilling Machines, Horizontal —*Cont*
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Stow Mfg. Co., Binghamton, N. Y.
Vandyck Churchill Co., New York.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Betts Mach. Co., Wilmington, Del.
Bullard Mach. Tool Co., Bridgeport, Conn.
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McCabe, J. J., New York.
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Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Warner & Swasey Co., Cleveland, Ohio.

Boring Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Fairbanks Co., Springfield, Ohio.

Boxes, Tote
Lyon Metallic Mfg. Co., Aurora, Ill.

Brackets, Lamp
Standard Welding Co., Cleveland, Ohio.

Brakes, Magnetic Friction
Electric Controller & Supply Co., Cleveland, O.

Broaching Machines
Burr & Sons, John T., Brooklyn, N. Y.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Lapointe Mach. Tool Co., Hudson, Mass.

Bulldozers
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
National Machinery Co., Tiffin, O.
Prentiss Tool & Supply Co., New York.
Toledo Machine & Tool Co., Toledo, Ohio.

Cabinets, Tool
Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Lyon Metallic Mfg. Co., Aurora, Ill.

Calipers
Athol Mach. Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Sawyer Tool Mfg. Co., Fitchburg, Mass.
Slocomb Co., J. T., Providence, R. I.
Smith Co., Ernst G., Columbia, Pa.
Starrett Co., L. S., Athol, Mass.

Cams

Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum

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Carriers

Lamson Consolidated S. S. Co., Boston, Mass.

Case-Hardening

Rogers & Hubbard Co., Middletown, Conn.

Castings, Brass and Bronze

Lumen Bearing Co., Buffalo, N. Y.
Nolte Brass Co., Springfield, O.
Phosphor Bronze Smelting Co., Philadelphia, Pa.

Castings, Die Molded

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Castings, Iron

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Fairbanks Co., Springfield, O.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Hopson & Chapin Mfg. Co., New London, Conn.
Poole Co., J. Morton, Wilmington, Del.
United Engineering & Fdry. Co., Pittsburg, Pa.

Castings, Motor

Brush & Hudson, Brooklyn, N. Y.
Harrison, H. K., St. Paul, Minn.
Steffey Mfg. Co., Phila., Pa.

Castings Steel

Bethlehem Steel Co., So. Bethlehm, Pa.
Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Kent & Co., Edwin R., Chicago, Ill.

Cement, Cast Steel

Clark Cast Steel Cement Co. Shelton, Conn.

Centering Machines

Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Hendey Mach. Co., Torrington, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
National Machine Co., The, Hartford, Conn.
Phœnix Mfg. Co., Hartford, Conn.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer

Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving

Baldwin Chain & Mfg. Co., Worcester, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Cullman Wheel Co,, Chicago, Ill.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
Whitney Mfg. Co., Hartford, Ct.

Chisels, Cold

Hammacher, Schlemmer & Co., New York.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Chucking Machines

American Tool Wks. Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Mach. Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, Ohio.
Potter & Johnston Mach. Co., Pawtucket, R. I.
Warner & Swasey Co., Cleveland, Ohio.

Chucking Machines—*Cont.*

Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.
Windsor Mach. Co., Windsor, Vt.

Chucks, Drill

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Brown Co., R. H., New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Horton & Son Co., E., Windsor Locks, Conn.
Jacobs Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
National Tool Co., Cleveland, O.
Niles-Bement-Pond Co., New York.
Oneida National Chuck Co., Oneida, N. Y.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
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Trump Bros. Mach. Co., Wilmington, Del.
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Westcott Chuck Co,, Oneida, N. Y.
Whitney Mfg. Co., Hartford, Ct.
Whiton Mach. Co., D. E., New London, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Chucks, Lathe

Cushman Chuck Co., Hartford, Conn.
Davis Machine Co., W. P., Rochester, N. Y.
Gisholt Mach. Co., Madison, Wis.
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National Tool Co., Cleveland, O.
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Oneida National Chuck Co., Oneida, N. Y.
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Union Mfg. Co., New Britain, Ct.
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Chucks, Planer

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Skinner Chuck Co., New Britain, Conn.
Westcott Chuck Co., Oneida, N. Y.

Chucks, Split

Hardinge Bros., Chicago, Ill.
Rivett Lathe Mfg. Co., Boston, Mass.
Westcott Chuck Co., Oneida, N. Y.

Circuit Breakers

Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps

Billings & Spencer Co., Hartford, Conn.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Tudor Mfg. Co., Worcester, Mass.

Clutches, Friction

Caldwell, Son & Co., H. W., Chicago, Ill.
Cresson Co., Geo. V., Phila., Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Wood's Sons Co., T. B., Chambersburg, Pa.

Clutches, Magnetic

Electric Controller & Supply Co., Cleveland, Ohio.

Coal Handling Machinery

Link-Belt Co., Philadelphia, Pa.

Coils

Standard Welding Co., Cleveland, Ohio.

Collectors, Pneumatic

Sturtevant Co., B. F., Boston, Mass.

Compound, Pipe Joint

Dixon Crucible Co., Joseph, Jersey City, N. J.

Compound, Slushing

Warren Bros. Co., Boston, Mass.

Compressors, Air

Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Boston, Mass.
Bury Compressor Co., Erie, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
International Steam Pump Co., New York.
Smith Fdry. Supply Co., J. D., Cleveland, Ohio.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas

Ingersoll-Rand Co., New York.

Conduit, Interior

Sprague Electric Co., New York.

Cones, Friction

Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps

Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work

Blanchard Mach. Co., Boston, Mass.
Chapman & Co., J. B., Springfield, Mass.
Skinner Ship Bldg. & Dry Dock Co., Baltimore, Md.
Turner Mach. Co., Danbury, Conn.

Controllers and Starters, Electric Motor

Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic

Lamson Consol. S. S. Co., Boston, Mass.
Link-Belt Co., Philadelphia, Pa.

Coping Machines

Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Cork Inserts

National Brake & Clutch Co., Boston, Mass.

Corundum

See Grinding Wheels

Cost Systems

American Mechanical Calculator Co., Cincinnati, O.

Cotters

Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores

Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.

Countershafts

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders' Iron Fdry., Prov., R. I.
Evans Friction Cone Co., Newton Centre, Mass.

Countershafts—*Continued.*

LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Mossberg Wrench Co., Central Falls, R. I.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction

Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing

Cresson Co., Geo. V., Phila., Pa.
Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose

Ingersoll-Rand Co., New York.

Couplings, Shaft

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cresson Co., Geo. V., Phila., Pa.
Electric Controller & Supply Co., Cleveland, Ohio.
Link-Belt Co., Philadelphia, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.
Wood's Sons Co., T. B., Chambersburg, Pa.

Cranes

Alliance Machine Co., Alliance, O.
Brown Hoisting Mach. Co., Cleveland, Ohio.
Case Mfg. Co., Columbus, O.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Maris Bros., Philadelphia, Pa.
Nichols, Wm. S., New York.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Smith Fdry. & Supply Co., J. D., Cleveland, Ohio.
United Engineering & Fdry. Co., Pittsburg, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines

Niles-Bement-Pond Co., New York.
Underwood & Co, H. B., Philadelphia, Pa.

Crank Shafts

Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles

Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.
Smith Fdry. & Supply Co., J. D., Cleveland, O.

Crushers

Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

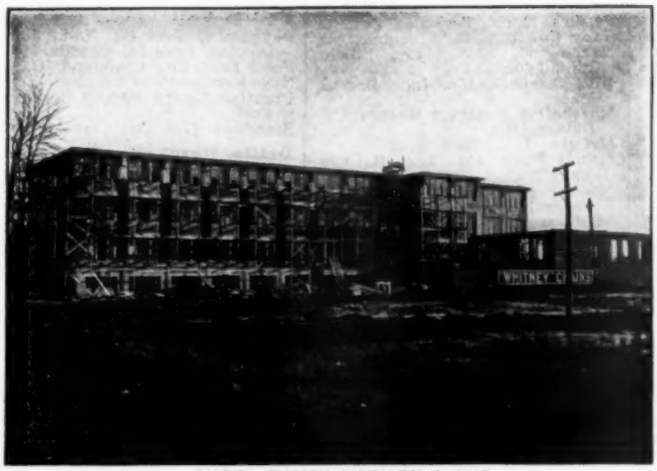
Cupolas, and Ladles, Foundry

Byram & Co., Inc., Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Smith Fdry. & Supply Co., J. D., Cleveland, Ohio.
Stevens, F. B., Detroit, Mich.

"Whitney" Chains

In 1907 will break all previous records for durability

We are moving into our new fire-proof factory building and will operate both plants, old and new, until we are fully settled so our production may be steadily increased with no interruption.



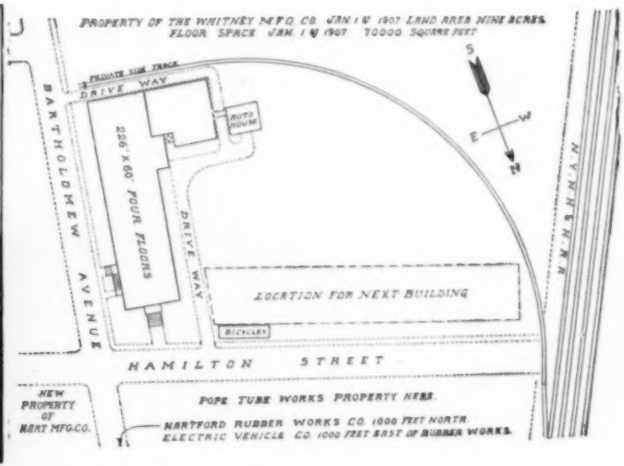

PROPERTY OF THE WHITNEY M'F'G. CO. JAN 1 W. 1907. LAND AREA NINE ACRES.
FLOOR SPACE JAN. 1 W 1907 70000 SQUARE FEET
DRIVE WAY
BARTHOLOMEW AVENUE
226' X 60' FOUR FLOORS
DRIVE WAY
AUTO ROOM
LOCATION FOR NEXT BUILDING
BICYCLES
HAMILTON STREET
NEW PROPERTY OF HART MFG CO.
POPE TUBE WORKS PROPERTY HERE.
HARTFORD RUBBER WORKS CO. 1000 FEET NORTH.
ELECTRIC VEHICLE CO. 1000 FEET EAST OF RUBBER WORKS.
PARKHAM

PHOTO. TAKEN JANUARY 6 1907

This cut gives an idea only of the plant which we believe will be the finest and most complete in existence for the manufacture of High Grade Driving Chains.

"Whitney" Chains

HAND AND WEIGHT FEED MILLING MACHINES, and The Woodruff Patent System of Keying

are Standard with most American Builders of Automobiles, Commercial Cars, Machinery, etc.

The Whitney Mfg. Co.

Hartford Connecticut

Cups and Covers, Oil

Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.
Winkley Co., Detroit, Mich.

Cups, Grease

Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cutters, Milling

Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Boker & Co., Hermann, New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Hardinge Bros., Chicago, Ill.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Nash Company, Geo., New York.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines

Armstrong Bros. Tool Co., Chicago, Ill.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Burr & Sons, John T., Brooklyn, New York.
Hill, Clarke & Co., Inc., Boston, Mass.
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Newton Mach. Tool Works, Philadelphia, Pa.
Nutter, Barnes & Co., Boston, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools

Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Fairbanks Co., Springfield, Ohio.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.
Western Tool & Mfg. Co., Springfield, Ohio.

Diamond Tools

American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Dickinson, Thos. L., New York.

Dies, Sheet Metal

American Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Globe Machine & Stamping Co., Cleveland, Ohio.
Kent & Co., Edw. R., Chicago, Ill.
Mossberg Wrench Co., Central Falls, R. I.
Swaine Co., Fred J., St. Louis, Mo.
Toledo Machine & Tool Co., Toledo, Ohio.
Wade Machine Co., Boston, Mass.

Dies, Sub-Press

Risdon Tool Works, Waterbury, Conn.
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Opening

Baker, S. S., Chicago, Ill.
Boker & Co., Hermann, New York.
Errington, F. A., New York.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Mach. Co., Springfield, Vt.
Modern Tool Co., Erie, Pa.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins

Winkley Co., Hartford, Conn.

Drawing Boards and Tables

Alteneder & Son, Theo., Philadelphia, Pa.
Economy Drawing Table Co., Toledo, Ohio.
Keuffel & Esser Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Rich, J. & G., Philadelphia, Pa.
Soltmann, E. G., New York.

Drawing Materials

Alteneder & Son, Theo., Philadelphia, Pa.
American Tracing Cloth Co., New York.
Keuffel & Esser Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Rich, J. & G., Philadelphia, Pa.
Soltmann, E. G., New York.
Technical Supply Co., Scranton, Pa.

Drafting Machines

Universal Drafting Mach. Co., Cleveland, O.

Drift Bolt Drivers

Ingersoll-Rand Co., New York.

Drilling Machines, Bench

Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Dwight Slate Mach. Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Ingersoll-Rand Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Boiler

American Tool Wks. Co., Cin., O.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, Ohio.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Multiple Spindle

American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co. B. F., Rockford, Ill.
Barnes Co. W. F. & John, Rockford, Ill.
Baush Mach. Tool Co. Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Fenn Mach. Co., Hartford, Conn.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Hardinge Bros., Chicago, Ill.
Harrington Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Moline Tool Co., Moline, Ill.
National Machine Co., The, Hartford, Conn.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Reed Co., Francis, Worcester, Mass.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.

Drilling Machines, Portable

Cincinnati Elec. Tool Co., Cin., O.
Coates Clipper Mfg. Co., Worcester, Mass.

Drilling Machines, Portable —*Continued.*

Gem Mfg. Co., Pittsburg, Pa.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Stow Mfg. Co., Binghamton, N. Y.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial

American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Detrick & Harvey Mach. Co., Baltimore, Md.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Fdry. Co., Jno. B., Cincinnati, O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Drilling Machines, Turret

Niles-Bement-Pond Co., New York.

Drilling Machines, Upright

American Tool Wks. Co., Cin., O.
Baker Bros, Toledo, O.
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Boynton & Plummer, Worcester, Mass.
Burke Machinery Co., Cleveland, Ohio.
Cincinnati Mach. Tool Co., Cincinnati, O.
Fenn Mach. Co., Hartford, Conn.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, Ohio.
Knecht Bros. Co., Cincinnati, O.
Knight Machry. Co., W. B., St. Louis, Mo.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Mechanics Machine Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
National Machine Co., The, Hartford, Conn.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Reed Co., Francis, Worcester, Mass.
Robertson Mfg. Co., Buffalo, N. Y.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Ct.
Wells Bros. Co., Greenfield, Mass.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Drills, Center

Morse Twist Drill & Machine Co., New Bedford, Mass.

Drills, Center—*Continued.*

Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand

Cincinnati Electrical Tool Co., Cincinnati, O.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic

Chisholm & Moore Mfg. Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
International Steam Pump Co., New York.
Niles-Bement-Pond Co., New York.

Drills, Rail

Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Foote-Burt Co., Cleveland, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet

Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Hisey-Wolf Mach. Co., Cincin., O.
Keystone Mfg. Co., Buffalo, N. Y.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

Drills, Rock

Ingersoll-Rand Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.

Drying Apparatus

American Blower Co., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos

Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
Eck Dynamo & Motor Works, Belleville, N. J.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. Co., Chicago, Ill.
Sprague Elec. Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincin., O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrical Supplies

Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Elec. Co., New York.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrically Driven Tools and Machinery

American Tool Wks. Co., Cin., O.
Cincinnati Electrical Tool Co., Cincinnati, O.
Crescent Forgings Co., Oakmont, Pa.
Electric Controller & Supply Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cincin., O.
Lincoln Motor Wks. Co., Cleveland, O.
Roth Bros. Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.

Elevators

Albro-Clem Elevator Co., Philadelphia, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.

Emery Wheels

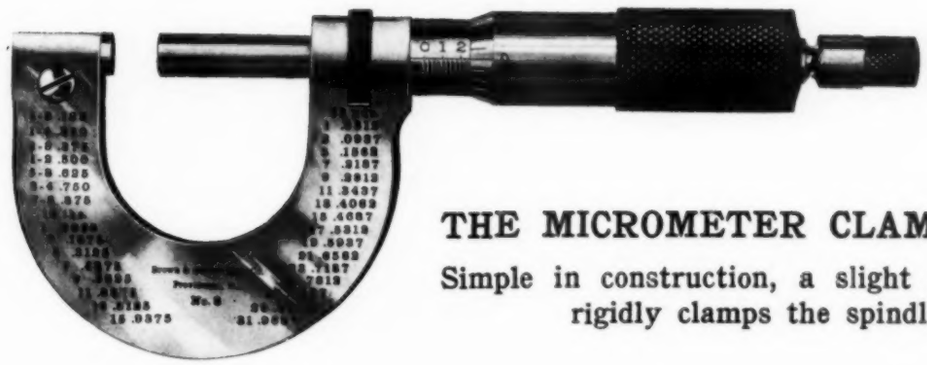
See Grinding Wheels

BROWN & SHARPE MFG. CO.

PROVIDENCE, R. I., U. S. A.

B. & S. MICROMETER CALIPERS

Conclusive Evidence of Their Superiority is Found in the Excellence of Their Design.



THE MICROMETER CLAMP RING

Simple in construction, a slight movement rigidly clamps the spindle.

DOES NOT ROTATE THE SPINDLE WHEN CLAMPING

IT is often desirable, after a measurement has been taken, to clamp the spindle to retain the setting and it is important that the spindle should not be rotated or moved longitudinally. The construction of the device is such that the possibility of disturbing the adjustment when clamping is entirely avoided.

TENSION ON MEASURING SPINDLE

Another excellent feature is that the tension on the measuring spindle can be adjusted without disturbing the adjustment of the screw and nut.

This is especially convenient when measuring a number of pieces for comparison, as sufficient tension can be put on the spindle to prevent its turning when the work is passed between the measuring points and at the same time the spindle can be left sufficiently free to allow of slight adjustments. The rotation of the spindle cannot alter the setting of the tension.

Catalog No. 107 of B. & S. Tools Sent Upon Application.

Emery Wheel Dressers
American Emery Wheel Co., Providence, R. I.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Dickinson, Thos. L., New York.
Heald Machine Co., Worcester, Mass.
International Specialty Co., Detroit, Mich.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

Enclosures, Tool-room
Hart & Cooley Co., New Britain, Conn.
Merritt & Co., Philadelphia, Pa.

Engineering Appliances
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Engineers, Consulting and Mechanical
Dodge & Day, Philadelphia, Pa.

Engineers, Electrical
Crocker-Wheeler Co., Ampere, N. J.
Dodge & Day, Phila., Pa.

Engines, Automobile
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Olds Gas Power Co., Lansing, Mich.

Engines, Gas and Gasolene
Automatic Mach. Co., Bridgeport, Conn.
Backus Water Motor Co., Newark, N. J.
Blaisdell Machinery Co., Bradford, Pa.
Foos Gas Engine Co., Springfield, Ohio.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Jacobson Mach. Mfg. Co., Warren, Pa.
Mathews, Hugh, Kansas City, Mo.
New Era Gas Engine Co., Dayton, O.
Olds Gas Power Co., Lansing, Mich.
St. Marys Mach. Co., St. Marys, Ohio.
Struthers-Wells Co., Warren, Pa.

Engines, Steam
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Garden City Fan Co., Chicago, Ill.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Engravers
Bormay Engraving Co., New York.
Standard Engraving Co., New York.

Engraving Machinery
Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads
Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition Machinery
Machinery Exchange, Boston, Mass.
Philadelphia Bourse, Phila., Pa.

Expanders, Tube
Nicholson & Co., Wm., Wilkes-Barre, Pa.

Extinguishers, Fire
Badger & Sons Co., E. B., Boston, Mass.

Factory Equipment
Lyon Metallic Mfg. Co., Aurora, Ill.

Fans, Electric
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
Garden City Fan Co., Chicago, Ill.
General Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Feathers
Standard Gauge Steel Co., Beaver Falls, Pa.

Files and Rasps
American Swiss File & Tool Co. New York.
Barnett Co., G. & H., Phila., Pa.
Hammacher, Schlemmer & Co., New York.
Heller Bros. Co., Newark, N. J.
Nicholson File Co., Prov., R. I.
Reichheim & Co., E. P., New York.

Filler, Iron
Felton, Sibley & Co., Phila., Pa.
Smith Fdry. Supply Co., J. D., Cleveland, Ohio.

Filing Machines
Cochrane-Bly Co., Rochester, N. Y.
Detrick & Harvey Mach. Co., Baltimore, Md.
Henry & Wright Mfg. Co., Hartford, Conn.
Simplex Mfg. Co., New York.

Flexible Shafts
Chicago Flexible Shaft Co., Chicago, Ill.
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American Gas Furnace Co., New York.
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Furnaces, Gas
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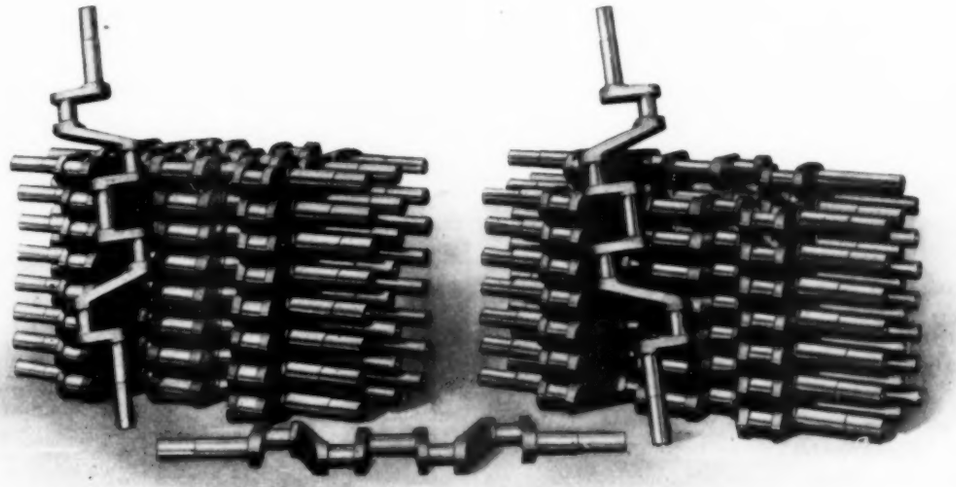

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Heald Mach. Co., Worcester, Mass.

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Cincinnati Electrical Tool Co., Cincinnati, O.
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Tindel-Morris Co., Eddystone, Pa.

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Attaching Fixtures to Concrete

Showing Efficient Methods for Attaching Light and Heavy Hangers to the Ceilings of a Large Machine Shop

BY L. P. ALFORD

At page 697, Vol. 29, Part 2, of the AMERICAN MACHINIST, under the heading "Editorial Correspondence," is a description of a device for attaching shaft hangers to a concrete building. The principle there illustrated was worked out by me in a different form about 3½ years ago, and the devices then and since used form the subject matter of this article. The devices were worked out for the United Shoe Machinery Company in connection with its plant at Beverly, Mass.

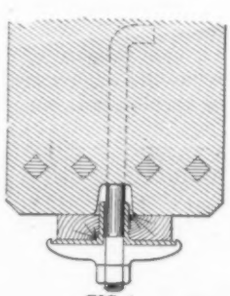


FIG. 1

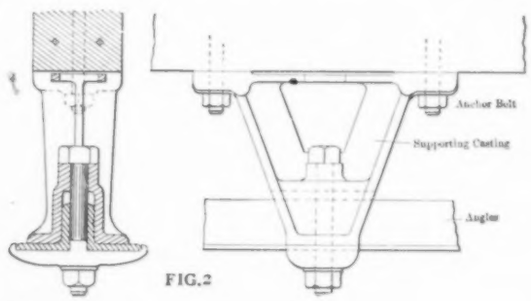


FIG. 2

HOW THE SLOT IS SECURED

In general the fixtures which were to be supported were divided into two classes, which may be called *heavy* and *light*. Under the classification *heavy* are main-line shaft hangers, countershaft stringers, main electric-wire structures, and hoist and trolley rails. Under the classification *light* are electric-wire molding, electric-light fixtures and small piping.

Considerable time was spent in the early part of the year 1903 in a study of methods and devices which had been used as a solution of the problem we were studying. Little of value was discovered. The embedding of anchor bolts or anchor nuts in predetermined locations to support specific fixtures, referred to in the article at page 697, was clearly an impracticable method for meeting our conditions.

Our machine-tool equipment contained upward of 2500 machines. Their countershafts, together with the necessary main-line shafting and attendant fixtures, had to be supported. It was impossible to predetermine the location of all these machines, and, besides, considerable floor area was reserved for machine tools on order and for growth.

These facts, together with the ever changing character of the manufacturing equipment and departments, showed that an elastic and universal system of ceiling fixture supports was needed over all machine-shop areas. Furthermore, to be successful, the system of supports must have its connections to the concrete-ceiling members provided when the concrete is poured, for the drilling or cutting of the concrete after it is set is unwise. The cost of this connection to the concrete must be a small part of the entire cost of the device, so that there will be only a small investment over unoccupied areas. Thus the main part of the device must be capable of being erected and removed at will without affecting the building construction.

No radical changes in the design of the concrete members were deemed advisable. To accompany the fire-resisting qualities of the concrete, it was logical to make the supporting devices as far as possible of metal.

DEVICE FOR HEAVY FIXTURES

These fixtures are of such a character that they can be arranged to be supported at regular intervals. In the buildings in question the bays are 20 feet on centers, so that the points of support arranged themselves naturally at bay limits and midway between, or 10 feet apart. The first device developed was a cast-iron T-slot to be cast into the lower portion of the concrete-ceiling members and flush with their lower faces. This device was never carried beyond the drawing stage, as it failed in several important particulars to meet the principles laid down.

The device finally adopted consists of a series of metallic slots running crosswise of the building, with a flat lower face, against which fixtures can be bolted by means of T-headed bolts. These bolts have their T-heads resting on the upper faces of the steel members forming the slot. The steel members forming the slot are fastened to the concrete-ceiling members by means of cast-iron clamps and anchor bolts. The anchor bolts are set in the concrete forms just before the concrete is poured, and are thus firmly embedded in the building structure. This device satisfies the principles which we deemed essential.

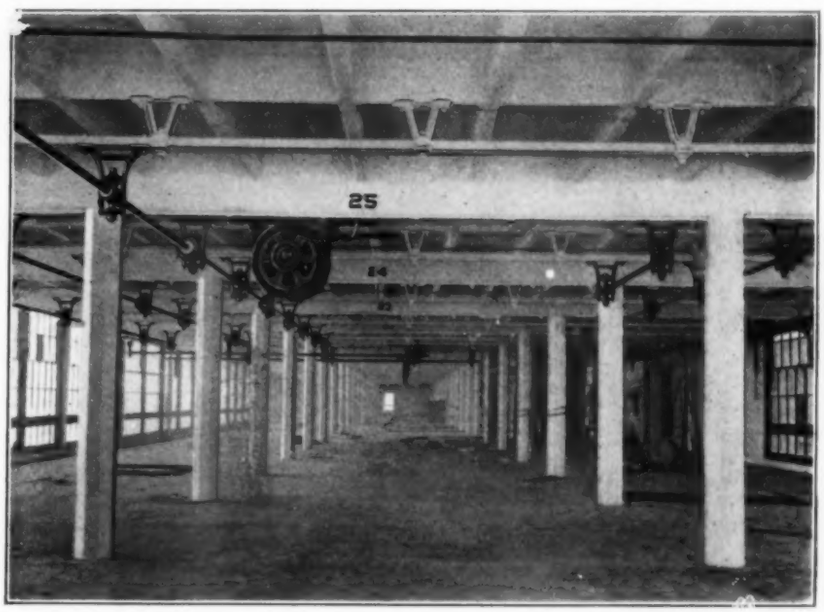


FIG. 3. SLOTS IN PLACE IN THE CEILING

Fig. 1 shows a cross section of a main concrete girder, with the slot device attached. These girders are 20 feet apart,

thus defining the bays. The metallic slot is formed of two angles, with the vertical legs facing and spaced apart, so as to form a slot between. The horizontal legs present a broad flat surface. Wooden strips are between the angles and the concrete. These were put in to absorb vibration, but were found to be unnecessary. The embedded anchor bolt and cast-iron clamp fasten the device securely in

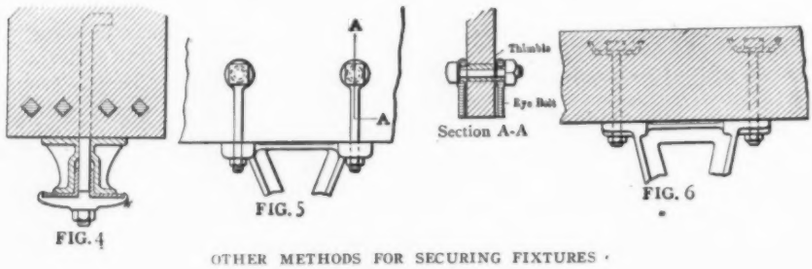


FIG. 4 FIG. 5 FIG. 6

OTHER METHODS FOR SECURING FIXTURES

position. The angles used were 2x2½x¼ inch, with the 2-inch legs vertical and spaced 1 inch apart. The anchor bolts were ¾ inch in diameter and spaced about 3 feet apart. A groove in the lower face of the girder receives the heads of the T-head fixture-supporting bolts. The structure is safe for a load of 2000 pounds and will sustain ordinary shafting loads without undue deflection.

The expense necessary when constructing the concrete shell of the building is the cost of the bolts, setting of bolts and molding the groove. The slot itself can be put up at any time as desired.

Fig. 2 shows the metallic slot attached to a concrete bridging beam. These beams are midway between the girders, and, as they are higher, a cast-iron hanger is necessary to bring the slot on a level with the slot attached to the girder. These angles are 2½x3x5/16 inch and are spaced about 6 feet on the centers of the supporting castings. Fig. 3 shows these slots in place on the ceiling of a large room, and line shafting fastened thereto.

Another girder cross section is shown by Fig. 4 without a groove in its lower face, but with a spacing casting, so that the slot is some little distance from the concrete. This has one advantage over the device of Fig. 1 in that the head of the T-bolt may be seen.

In a few cases thin beams were encountered, beams so thin that it was impracticable to set anchor bolts. In these cases thimbles of pipe were set and slot hangers attached, using eye-bolts, as illustrated by Fig. 5. The method used for setting anchor bolts in flat or slab floors is shown by Fig. 6.

I-beam hoist or trolley tracks are supported from this slot system with ease. Fig. 7 is a photograph of one erecting bay served by two such tracks.

Figs. 8 and 9 show two details of supports, the first being the cast-iron clamp fastening the countershaft stringers to the slot system, and the second a cast bracket and adjustable fulcrum fastened upon these stringers for the countershaft shipper lever. The style of bolts used is shown by Fig. 10. The one with the rectangular head was designed for the groove in the girder, the second for the other locations. Under each head is a squared shoulder to prevent the turning of the bolt in the slot.

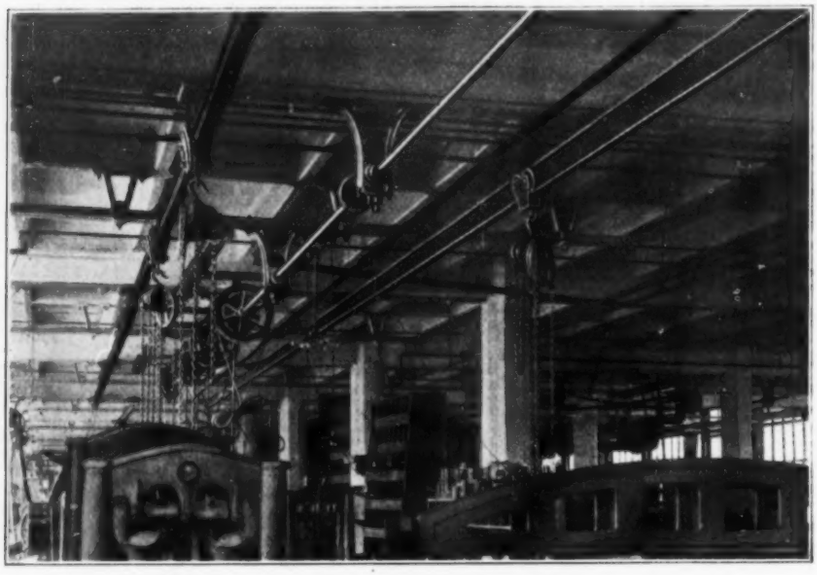


FIG. 7. SHOWING I-BEAM TRACKS

Thus it will be seen that all of the *heavy* fixtures are supported with ease from the slot system. The devices are comparatively inexpensive. The angles are used as they come from the rolling mill, the castings as they come from the foundry, and the bolts are rough commercial bolts. There is no machine work in connection with its erection.

Device for Light Fixtures

No device was worked out for supporting the *light* fixtures when building the original plant, and the installing of these fixtures was found to be a slow and expensive operation. This led to the development of a system for their support.

These fixtures, unlike the heavier ones, do not occur in any regular arrangement as regards supports, but may require a location at any point over the manufacturing area. Thus an opportunity for supports at intervals of 10 feet does not meet the requirements. A successful system for this purpose must cover the entire manufacturing area, but the loads to be supported are insignificant.

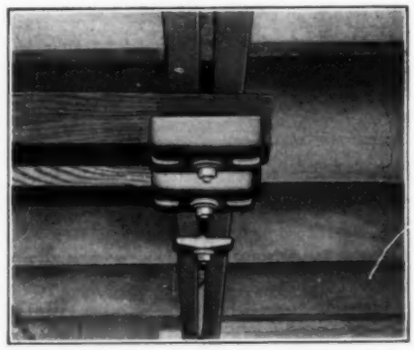


FIG. 8. SHOWING CAST-IRON CLAMP

Referring to Fig. 3, beams will be noted running from girder to girder. These are spaced comparatively near together, about 3 feet on centers, and thus offer an opportunity for the attaching of a fixture-supporting device which will cover all of the floor area. Such a supporting device must be inexpensive, simple in construction and easy to erect or remove. It must not present any disfigurement of the beams as regards that part of the device which is a part of the concrete beams themselves, as fixtures will be attached here and there without any regular order, and a large portion of every beam will have no fixtures attached.

The device which was worked out and adopted consists in molding two small half-round grooves, one in each of the vertical faces of the beam and near the bottom. Suitable, inexpensive clamps are easily designed to enter these grooves and support the various fixtures.

The grooves were formed by nailing strips of ½-inch half-round molding to the inside of the beam forms, 1½ inches

from the bottom. These strips drew with the forms when the forms were removed, leaving the grooves properly cast. Being small, uniform and in the vertical faces of the beams, the grooves are hardly noticeable and present no disfigurement whatever.

Fig. 11 shows a cross section of a beam, with the grooves in the side and a clamp for holding electric-light-wire molding. The clamp has two slots punched in its horizontal part, so that two strips of molding may be butted beneath the clamp and each end fastened by a bolt. This simplifies the splicing of molding for long sections.

In Fig. 12 we see a pipe supported by the beam grooves with an adjustable hanger. The strength of the grooves was found by experiment to be far in excess of the clamps, which were designed of ample proportions for the service required. These

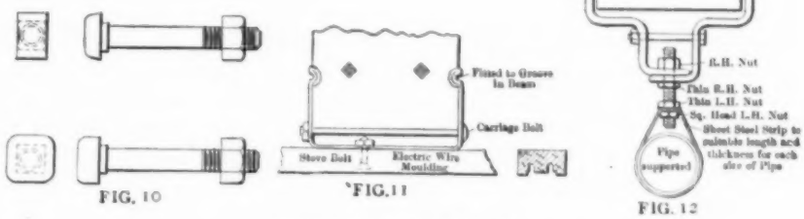


FIG. 10 FIG. 11 FIG. 12

SECURING LIGHT FIXTURES

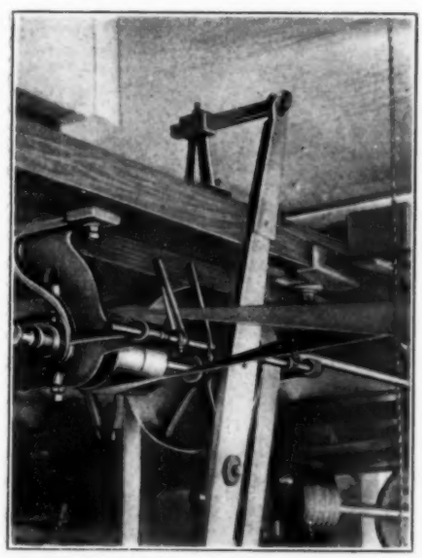


FIG. 9. SHOWING SHIPPER-LEVER FULCRUM FASTENED TO STRINGER

experiments showed that the grooves would sustain a load of from 250 to 300 pounds at any point with an ample factor of safety. This of course is a much greater strength than is necessary for any loads for which they are intended to be used.

The photograph forming Fig. 13 was taken from a section of ceiling having some strips of molding in place and attached to the grooved beams by the device illustrated in Fig. 1. Toward the bottom and at the left will be noted a section of the metallic slot, with the spacing casting as shown in section by Fig. 4.

A good idea of the way in which the fixtures appear when supported by the devices described can be obtained by referring to Fig. 14, which is from a photograph of a portion of the ceiling over a lathe department.

The metallic-slot device has had a trial of two years over a manufacturing area of upward of 325,000 square feet, with success. During last year it was installed over 180,000 square feet of additional manufacturing floor area, giving a total of over half a million square feet. The device was also installed in the power-house building to provide support for the piping.

Although the grooves in the sides of the beams were not molded in the buildings of the original plant, in the construction work of last year nearly 100,000 feet of this groove was cast, with success. By the use of the two devices which have been described it is possible to support all classes of fixtures from the concrete ceilings of machine-shop buildings with entire success, and avoid all objectionable drilling or cutting of the concrete, which, if done to any great extent, will weaken the structure.

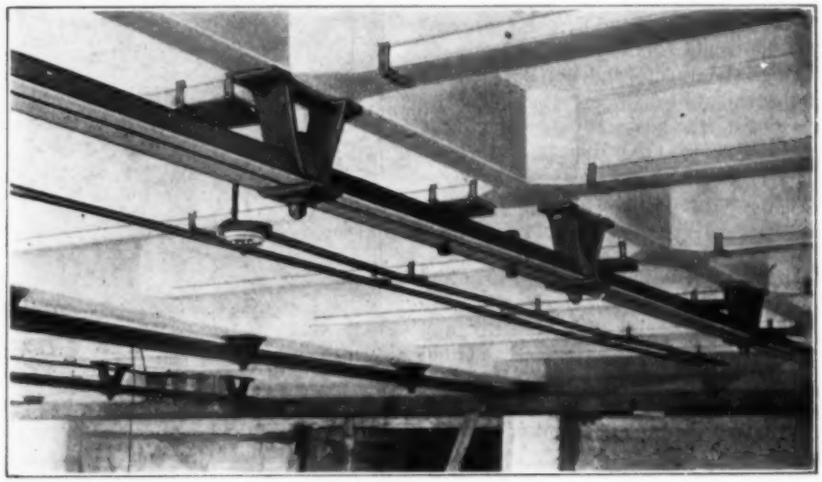


FIG. 13. SHOWING DEVICE FOR FASTENING LIGHT FIXTURES

It should be stated in closing that the metallic-slot device is covered by a patent application.

It is stated that for an average value of 6300 British thermal units, peat shows a fuel cost 50 per cent. greater when used in solid form to make steam than in a producer with a gas engine. Costs of plants for the two methods are about the same.—*Power*.

Sammy's Shop—Experience with Partners

The opening up of a new oil pool in Sammy's district had the effect of making a very large amount of business, and it was business that paid almost any price as long as the work was right and got out in double quick time. When wells are starting off at from 50 to 100 barrels an hour, some of them, and every man who is drilling thinks that his will be in that class, there is not much haggling as to price. This boom in the oil field, besides being a little gold mine for Sammy, made money very plenty for other people; some of them were looking around for safe investments, and this shop attracted their attention.

After having struggled along for several years and barely keeping afloat much of the time, to Sammy the prospect of being able to go along with unlimited capital (the amount the others offered to put in seemed like that to him), and to have someone else to take care of the office details, while the work came rolling in without having to be hunted for, was very alluring.

A New Business Arrangement

The proposition was this: Three men with money would put into the business an amount equal to twice what it would be worth at the time with all of the debts paid, and in return they were to own one-fifth apiece, or three-fifths of the whole. Part of the money was to be used to get new tools and part to pay off debts. Mr. Smith was to be secretary of the company and have charge of the office work. Mr. Jones was to be treasurer, and the funds of the combination were in his hands. Mr. Brown was content to act in an advisory capacity. These men were all successful men in the world. Mr. Smith was a broker in oil, and any other thing that offered a commission. Mr. Jones was a real estate and insurance agent. Mr. Brown had been a farmer until the oil on his land had made him rich. They were all oil producers, and could furnish enough work to keep a small shop going. The price offered seemed to Sammy to be a good one, and the division of labor also offered advantages, and in a short time he had three partners.

Material Progress

With a chance to put all of his time and attention into the shop work, Sammy got out the work at a rate that was very gratifying to himself. Several new tools increased the capacity of the shop, and made it easier to do good work. Of course, Mr. Smith did come out quite often to ask questions, and it took a lot of explaining to get him to understand why Jake's time was not always charged at the same rate on different jobs, and how he could work fourteen hours in some ten-hour days and not do it in all of them; but then, Sammy reasoned, he was new to the business, and naturally it would take him some time to find everything out, and so he took all the questioning very good naturedly.

Trouble Caused by Partners

There was one thing that did give him real concern, though. He had always tried to be fair with each customer, and now he found that no matter what promises he had made as to time of getting out work his partners insisted that any work they sent in should be done at once. This put it so that he found that he did not dare to make a positive promise because he never knew whether or not he would be able to keep it. He had another surprise one day when he tried to find out how much money the concern was making. He found that his share was much less than it had been when he was entire owner. At first he could hardly believe this to be possible. After considerable heated talk, he found out that while he had been drawing wages for his work at a rate a trifle better than that paid for a good machinist, Mr. Smith had been drawing a very liberal salary as secretary, and Mr. Jones one for acting as treasurer, while all three had been getting a liberal discount on work done for themselves. In the case of Mr. Smith a young man had been put into the office after a few months, and he did the actual work of bookkeeping and was paid by the company.

Sammy Has His Eyes Opened

Sammy felt that he was not being treated fairly, and was furious, but he was given to understand that he was wrong in his ideas. A comparison of the rates paid to Mr. Smith and Mr. Jones with rates paid by large concerns for services of a like kind showed that the rate was really nominal, and that the real trouble with Sammy was that he had been doing an amount of high-class work for nothing—that is to say, Mrs. Sammy had been doing most of it.

In regard to the work done for the partners it was pointed out that this work came in without solicitation, and the bills were paid promptly without question, and without the time of a collector, and that these things cost money, which was in this case saved by the man sending in the work, and it was no more than right that he should have it. Again Sammy found that when Mrs. Sammy had been doing collecting she had been saving him money at a rate he had not known.

Compensation for Labor

After taking time to consider these things, Sammy saw that it was not reasonable for him to receive pay by the hour for all work he did, and for his partners to render services for nothing just because it was hard to reduce them to a time basis. He could also understand that his profits before this time had largely been on paper, while now although they were much smaller they were more nearly real. When he worked long hours in the shop he got the returns in wages, while before, when he had spent his evenings in trying to get work to keep things moving, or pay for that already done, it was hard to figure out just how or when he ever got anything for it. In spite of all his good sense and reasoning about these things, Sammy was not satisfied or contented. Compared to himself his partners were men of education and business experience, and they had a way of making him feel this.

A Change in the Method of Buying

Perhaps it was not intentional on their part to make him feel that he was being set aside, but they were so sure of their own judgment that they did not think it necessary to consult him on many of the matters that came up. If a salesman came in and convinced him that a certain new appliance would be a good thing to use, Mr. Smith had to be seen and convinced that it was an improvement, before it could be ordered, and as Mr. Smith was not a mechanic, this was often hard work; and if it was bought Mr. Smith then wanted to see, in dollars and cents, that it had been a money maker. Every shop manager knows how hard it would be for him to show the exact part that good tools, high-speed steel, good men, a

FIG. 14. PORTION OF CEILING IN LATHE DEPARTMENT

well planned shop system, and such things each have in the reduction of costs. We all feel that we cannot get along without them, yet every shop-bred manager knows that any figures showing a rate of saving for any one of them is only an estimate, and that that estimate is never capable of accurate proof.

If a salesman was to see and convince Mr. Smith the thing might be ordered without any consultation with Sammy, but he was expected to make the saving with it that the salesman said was sure to follow its use.

These things were bad enough, but they were not the worst, nor the most aggravating. When it came to interference with the men in the shop Sammy was ready to fight.

Some Oil-country Workmen

The gang that he had collected together might not have made a very imposing appearance on dress parade at a reception, nor have ranked very high in a civil-service examination; in their use of language forceful expression was apt to take the place of elegance, while not one in the bunch would have any chance in a beauty show; yet he felt that each one was a treasure in his way. Albert could be depended upon to dig out results from any kind of a job that was given to him, even if he did put in a miserable time-sheet. (The business had grown to where the slates had given way to sheets with a printed heading.) Bill had a voice on him like a fog-horn, and could not express himself without profanity; but he was strong and willing, and never kicked at any hard work or long hours. Some of the men hinted that if Jake ever changed his shirt or washed his neck there was no outward evidence of the fact; but none of them ever hinted that a job had been found so dirty or disagreeable that he would not undertake it.

Other Handy Mechanics

Big Tom was a jack at all trades. He could do patternmaking or carpenter work. He was quite a blacksmith and something of a tinsmith. He could make a fair drawing and had "a pretty good head" for handling outside jobs, and could go out and give estimates on contemplated work. He was not the best machinist in the world, but was a very good man for filling in. Little Tom was known and liked by the lease men all over the country. He knew every boiler and engine house and the quickest way to get there, which is quite a thing in a country covered with woods and broken up with hills and streams. He knew the man who wanted the fine job, and the one who didn't, and was asked for more often than any man in the shop.

Changes in the Force

Sammy knew the virtues of each one of these men, and of all the others. He had tested and tried them, and knew how to use them. He did not try to use one where it was improper, any more than he would try to drive nails with a saw or eat soup with a fork. The criticisms offered by the others and directed against the men were like pin pricks, not very serious perhaps but extremely aggravating; but when Mr. Smith discharged Bill for cursing him in return for some remarks, and Jake quit because Mr. Smith told him that unless he kept clean he could not work there, Sammy nearly raised the roof. It did not quiet matters any when other men were hired to take the vacant places for they were hired by the other partners.

Two Valuable Men

One of them was a man with a lot of theory and no practical experience, but with an astonishing amount of "gall," and faith in his ability to instruct others. Big Tom kindly and considerately offered to thrash him the first day, in return for attention received. The other man was a fine singer. He sang in one of the churches, and was received in the best of society in return for exercising his musical ability. He used correct language, and wore old kid gloves to protect his hands. Little Tom suggested to the others that they club together and get a magnifying glass and present it to Sammy so that he might be able to find the work that this new arrival did, without straining his eyes.

Sammy Decides to Start Another Shop

The first man found lots to find fault with in the way the shop was conducted, and the partners believed much that he said. Their view-point and experience were so different from Sammy's that it was plain to see that there could be no harmony. The shop had been doing a good business, but according to the statements of the new man—and he was a man of education—it should have been done much better and more cheaply.

After one of the rows, which had come to be common, they offered to buy Sammy out, and he took their offer. He had wished for this, as he saw that he had made a great mistake in associating men with himself who were so totally different from what he was, and besides that he had found a better location for a shop. The ground could be bought, and it had both a street and a railroad frontage, and there was a road the length of one side. He made up his mind to buy it and start in alone again.

The Old Plant Moves

The partners believed that the new man would be a better man than Sammy for them, and then they had an offer to move the shop to another town. They formed an incorporated company, got a bonus for moving, and a reduction of taxes for a term of years, and a gift of land, and were able to unload a lot of the stock of the new company on the community, which had such a bad natural situation that they had to pay concerns for coming there. It might be interesting to follow their career up to the time of their death and burial as a company, but the record is a common one. As for Sammy, he spat on his hands and took a fresh grip. His wealth of experience had been largely increased.

W. Osborne.

Detroit River Tunnel

Mr. Mountain, the chief engineer upon the plans of the Detroit River Tunnel Company, which have just been approved by the Canadian Railway Commission, states that it is the most complete tunnel scheme he has ever seen. The project, which is to cost between $7,000,000 and $10,000,000, provides for the construction of two parallel tubes of iron to rest 65 feet below the surface of the water on beds of concrete, and to be flanked by concrete walls. These will give double tracks to enable the Michigan Central and Canada Southern trains to cross beneath the Detroit river.

The tunnel proper is to be 20 feet in diameter, and its roof will be 40 feet below the water, and the tracks will be laid upon huge beds of cement. The approaches on either side will be 18 feet high by 16 feet 6 inches wide, while the width of the portals will be about 60 feet. The length of the tunnel actually under the river will be 2625 feet. On the east side there will be an approach of 3200 feet of tunneling and 3300 feet of half tunneling. The west approach will consist of 2135 feet of tunneling and 1540 feet of half tunneling. There will be a 2 per cent. grade on the west side and 1½ per cent. on the east. It is intended to sink the iron tubes in sections, and then rivet them together and pump the water out. The trains running either way through the tunnel will be propelled by electric motors, which will prevent gases from generating and simplify the problem of ventilation. The tunnel will run from the Michigan Central station at Detroit, cross the river at the old ferry slips, and connect at Windsor with the Canada Southern Railway.—*Canadian Engineer.*

Among the things which they do better in Germany than here is the restriction of bill-board advertising, which, in Berlin, at least, is not permitted. A limited amount of public advertising is practiced, but it is restricted to a system of pillars or columns on the edge of the sidewalk at the principal street corners, but the bill-board nuisance as we have it is unknown. The privilege of erecting and using these advertising columns is sold to the highest bidder, and from the privilege the city of Berlin realizes about $95,000 per annum.

The Washington Naval Gun Factory—VI

The Forge Shop—Equipped with Gas-fired Forges and Furnaces—The Secondary-mount Shop, Where Fitting on Smaller Guns Is Done

BY HENRY J. KENNEDY

After completing the circuit of the quadrangle described in the previous article, we leave the gun-carriage shop and step across Kennon street into the blacksmith shop. This building, of which an exterior view is given in Fig. 54, and a general interior view in Fig. 55, was completed in 1902; it is of brick, 80 feet by 265 feet 2 inches, and 33 feet 7 inches high at the eaves. It has a complete equipment for making the large variety of forgings for the breech-mechanism parts of the guns and for the mounts, accessories, tools, etc. It is furnished with an overhead electric traveling crane made by the Morgan Engineering Company, with a main-hoist capacity of 25 tons, and has also two electric jib cranes each of 10 tons capacity.

FIG. 54. FORGE SHOP FROM THE SOUTHWEST

Steam and Drop Hammers, Etc.

There are several hammers for heavy work, the largest of which is a Dudgeon double-frame 10-ton steam hammer having a striking force equivalent to about 55 tons, when top steam of 75 pounds per square inch pressure is used. This hammer is shown in Figs. 55 and 56 (and, by the way, the cast-iron beam, which has been so thoroughly discussed of late in the AMERICAN MACHINIST, is here exemplified by a pretty substantial specimen). The remainder of the hammer equipment includes a Morgan and a Dudgeon seven-ton single-frame steam hammer, with striking force equivalent to about 25 tons when top steam is used; and four single-frame four-ton steam hammers, equivalent to about eight tons when top steam is used. There are two Bement-Miles "steam drop hammers," with 5500-pound heads, striking force equivalent to about 22 to 25 tons; three board drop hammers with 1500-pound heads, built by Pratt & Whitney, two of which are shown in Fig. 57. Wheels for the gun carriages are drop forged under these hammers. There are also three trimming presses built by the Waterbury Farrel Foundry and Machine Company, a Bradley cushion hammer, a Buffalo Forge Company No. 1½ bolt-heading machine, oil tank for tempering, cyanide tank for case-hardening, etc.

The Gas-fired Forges and Furnaces

An interesting feature of this shop is the equipment of gas-fired furnaces and forges. It is worth while to go into some details with reference to this fuel system, which is known as the Acme gas system. This plant was installed in 1898, soon after the first introduction of the process; before that time the forge shop had been equipped with coal furnaces and forges. As stated in the historical part of these articles, the demands made on the navy yard by the Spanish war were very heavy, and the doubling of the capacity of the forge shop per furnace and per man by the introduction of the improved fuel was exceedingly timely. The advantage of this fuel arises from its high flame temperature, its freedom from sulphur and other impurities, the great convenience possible in the application of the fire, and the accurate regulation which may be obtained, all of which make the gas very suitable for the high grade of work which the navy-yard forge shop is called upon to supply. However, this fuel is about 50 per cent. more costly than fuel oil, the distillate from which it is made costing, on the average, about twice as much per gallon. Table II gives the flame temperature and heating value of Acme gas, as compared with fuel oil and natural gas.

Fuel.	Comparative Flame Temperature on Scale Where the Flame of Hydrogen is Assumed to be 1000.	British Thermal Units in a Commercial Unit of Purchase.
Acme Gas.	870	128,320 per gallon of distillate.
Fuel Oil.	815	136,320 per gallon.
Natural Gas.	792	931 per 1000 cubic feet.

TABLE II. COMPARATIVE PROPERTIES OF DIFFERENT FUELS

There is a variety of gas-fired furnaces, many of which are shown in the accompanying illustrations. There are six small open forges for such small work as tempering and repairing tools, making small

chain link and forging small parts; and two case-hardening furnaces, made by the American Gas Company, for annealing small parts and case-hardening in small boxes. Some of these furnaces are shown in Fig. 58.

Besides 45 open blacksmith's forges (Figs. 55 and 59), there are three small closed furnaces, about 2x2 feet by 1 foot high, used for forging and welding heats on small but compact heavy pieces; and four closed furnaces of a very good design about 3x5 feet by 2 feet high, used for similar work on larger pieces.

Still larger forging and welding work up to pieces of 5000 pounds weight is heated in three large closed furnaces about 5x8 feet by 4 feet high, one of

FIG. 55. GENERAL VIEW OF FORGE SHOP SHOWING LARGE STEAM HAMMER, TRAVELING AND JIB CRANES, AND SOME OPEN FORGES

which is shown in Fig. 60, the door being partly open and showing the hot interior. In Fig. 61 is shown another large closed furnace for case-hardening and annealing large pieces, and small pieces packed in bone dust, some of the boxes for packing the latter being seen in front of the furnace. There is, moreover, a ground-level forge for making local heats and for very large and heavy pieces, and a special water-jacketed furnace for heating up very large rivets.

Fig. 62 is from a rough free-hand sketch illustrating the arrangement of the gas-fired furnaces. Along one side of the furnace runs the manifold *A*, from which the burners *B* enter horizontally into the furnace. *C* is a fire-brick deflector which is found to be a great aid in promoting perfect combustion. The gas and the air for its combustion come together at *D*, *E* being the gas pipe and *F* the air pipe; the air is supplied by the same blower which furnishes the air for the generators, but it is at this point at a little higher pressure than the gas entering through the pipe, because the latter has suffered a drop due to the passage through the generators.

The Gas and the Apparatus for Generating It

The gas consists of the vapor of light petroleum distillates, made by the evaporation of 68-70 gravity crude distillate of petroleum, consisting of hydrocarbons of the methane (marsh-gas, CH_4) series, principally C_6H_{14} (hexane), these vapors being taken up by, and mixed with, part of the air necessary for their combustion. The generating plant is located in a small brick building, south of the forge shop, shown on the plan, Fig. 2. The gas is made by forcing air through the distillates contained in the generators. In plants of more recent design, a positive high-pressure blower is ordinarily employed for this purpose, but in the Washington plant an air compressor or small blowing engine is used. The pressure there is about seven pounds per square inch because of the pipes being small and the necessity for forcing the plant; ordinarily it is intended to use in these plants a pressure of two pounds per square inch. The general arrangement of a plant for making this gas is shown diagrammatically in Fig. 63, which shows two generators and four gas tanks or driers.

The distillate, which is purchased in large quantities, is stored in large underground storage tanks, from which it is pumped once a day to the small subsidiary feed tank near the plant, from which a small steam pump is continually drawing a supply and pumping it into the first generator. The pump is kept running continually, a very little faster than necessary, to supply the consumption of oil, the excess flowing off through an inverted U-tube, which forms an overflow and automatically keeps the level of the oil in the first generator constant. The air from the blower is led by a pipe to a point near the bottom of the generator, from which it escapes and bubbles up through the distillate to the surface, carrying with it the lighter portion of the oil in the form of vapor. The oil in this generator is kept at a temperature of about 100 degrees by means of a flat steam coil placed in its bottom. From the first generator the oil flows by gravity to the second generator, which is lower, a constant level of the liquid being maintained by a float valve. The greater portion of the carburization of the air is done in the first generator; it is passed through the second generator in order that it may take up the heavier portions of the oil, which remain in the second generator until used, and for this reason the temperature in the latter is kept higher, being about 150 degrees Fahrenheit. From the top of the first generator

a pipe carries the air and gas to the bottom of the second generator, where it is allowed to escape through the distillate as before, bubbling up to its surface, and then being carried off through the "driers." The driers or washers are somewhat similar in construction to the generators, but have within them a series of steel plates thickly studded with small perforations; the passage of the gas through these perforations causes any distillate spray which it has carried from the generators in mechanical suspension to be deposited in the tanks, from which it is drained back automatically into the generators.

It is, of course, evident that if such a gas as this be allowed to become very poor, that is, if there be a great excess of air, it will become dangerously explosive. In order to afford a constant index of the richness of the gas, therefore, a pilot lamp is kept continually burning, and by the color of its flame (which should be blue) the proportion of air in the gas may be judged.

The full capacity of the plant is always available at the burners and furnaces, the gas cocks being turned on and off just as they would be if the gas were supplied by the mains of a public-service company. A simple device does away with the necessity of a large gas holder, while at the same time the supply of gas is automatically maintained equal to the demand; this consists of a relief valve placed on the line supplying air to the generators; the blower or pump is operated at a constant speed, and delivers its full capacity up to the point where is placed this relief valve, which is set at the pressure at which it is desired to carry the gas. The effect of not using the gas as fast as the plant is able to generate it will, of course, be to raise the pressure of the air, so that the relief valve is opened, and the excess amount of air escapes before it gets to the generators.

The Pattern Shop

The pattern shop, of which a portion appears in Fig. 15, is west of the forge shop. It was built in 1854, and is a brick building formed of two wings, one practically 200 feet long and the other 145 feet 8 inches, the joint area being 20,143 square feet. This is the first two-story shop which we have yet come to in the yard, unless the galleries in the gun shop can be considered as a second story. The upper story of this building is occupied as a pattern shop, while on the ground floor is done a variety of joiner work, such as the making of ammunition boxes, sight boxes, etc. Swabs or sponges of bristle and sheepskin for cleaning guns are also made in this building.

Passing the store houses (store No. 10 is a substantial structure 250 feet long), and the small building where the yard locomotives are housed and repaired, we come to

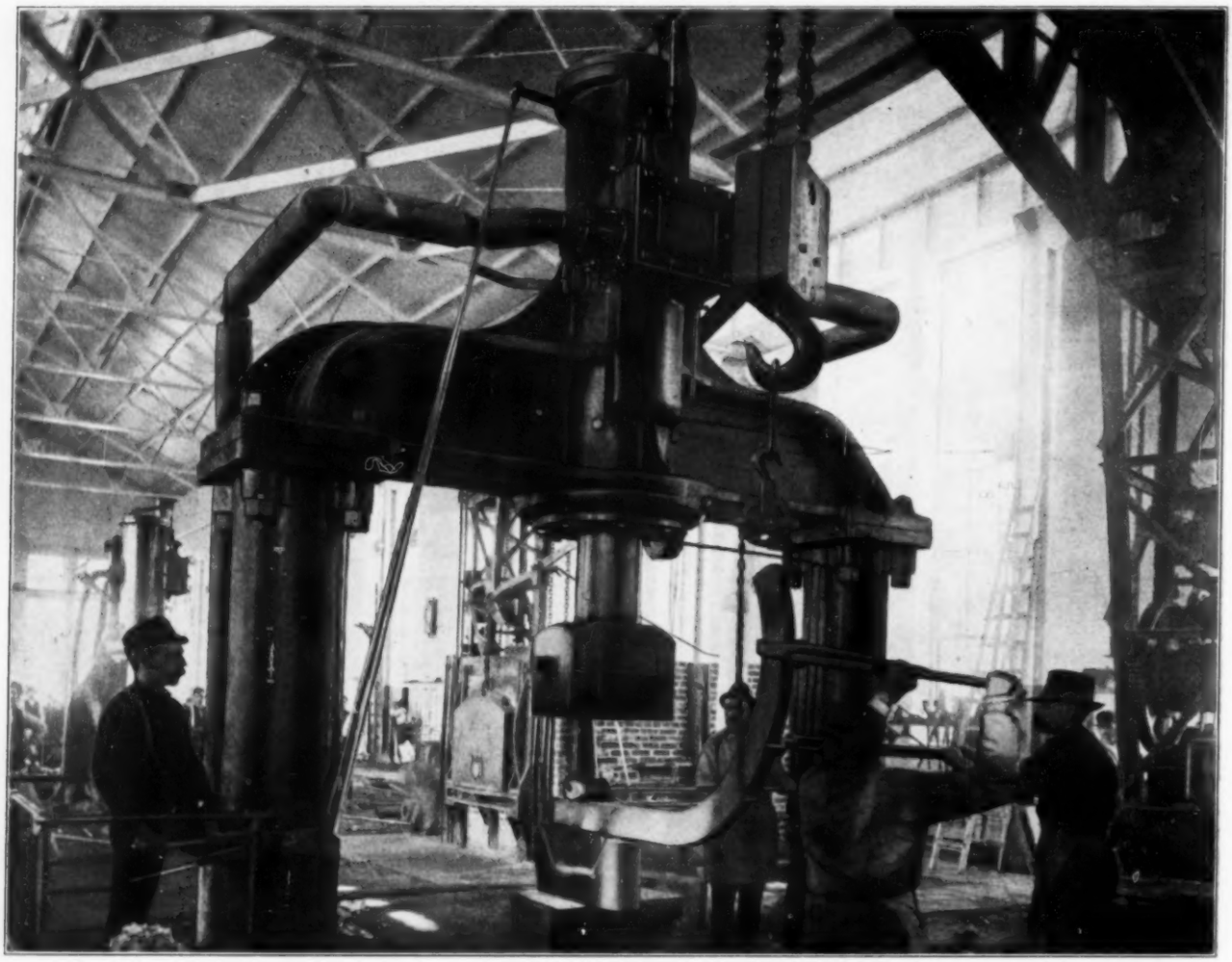


FIG. 56. THE LARGE DUDGEON STEAM HAMMER IN THE FORGE SHOP

The Secondary-mount Shop

The secondary-mount shop is located on the south side of Tingey street, in line with the erecting shop described in the sixth article. It is a one-story brick building 65 feet 2 inches by 251 feet, 39 feet 7 inches high at the eaves, and 16,357 square feet in floor space, and was built in 1898. As its name indicates, here is done the fitting work on breech mechanism, sights, mounts, etc., for the secondary-battery guns, and torpedo-launching tubes, both the submerged type and those which are placed above the water-line. A number of outer casings of torpedo tubes

may be seen in the foreground of Fig. 64, which is a view looking down the middle of the shop. To the left are four Bement, Miles & Co. slotters, of strokes from 24 inches to 12 inches, and tables from 40 inches to 24 inches. The first one is at work on the junction powder chamber for a torpedo tube, the second machine is slotting the breech for a three-pounder Hotchkiss gun, the third is slotting the breech of a one-pounder, and the fourth is working on the recoil chamber of a one-pounder. The large white, painted cross on the door in the end wall of the shop was used as a target at which to aim the gun in making some experimental adjustments of sights.

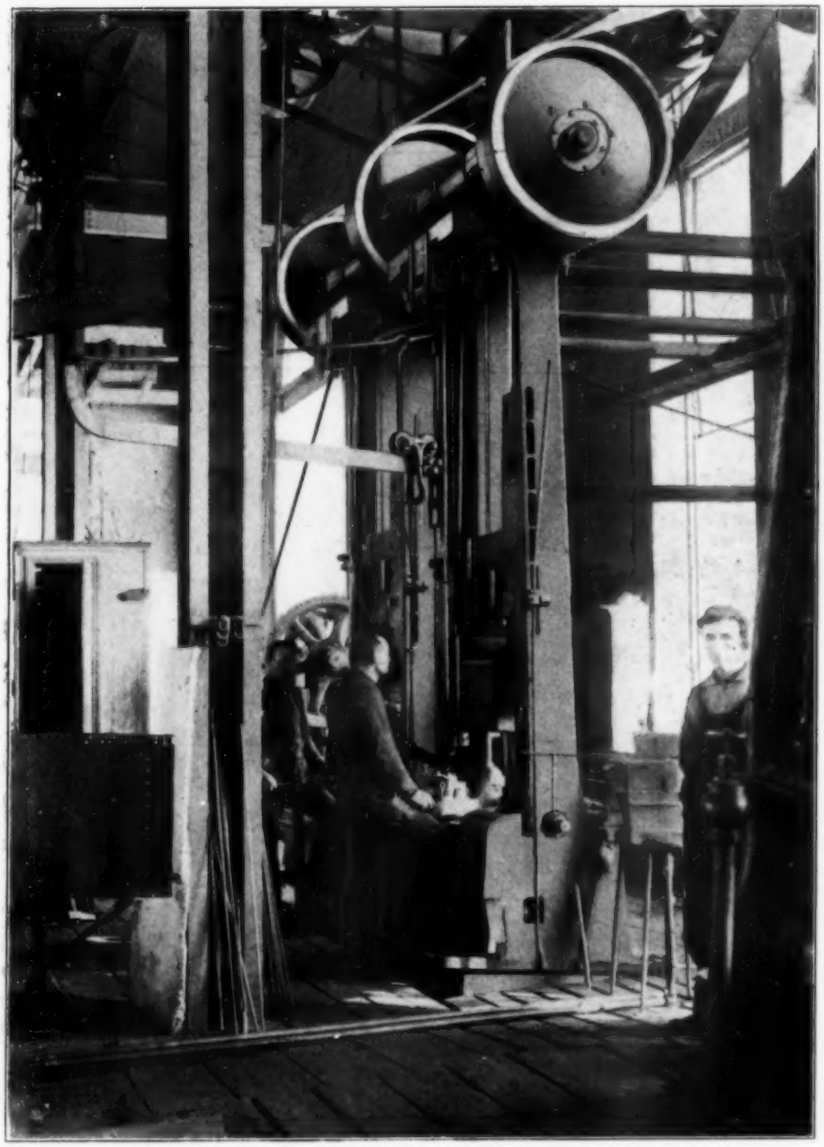


FIG. 57. TWO OF THE DROP HAMMERS

A three-pounder semi-automatic gun is shown on the left in Fig. 65; its breech was bored on a Bement, Miles & Co. horizontal boring, drilling and milling machine, of which six appear in the picture; some of them are also shown in Fig. 64. They are all of the same size and have tables 54x36 inches, and 41 inches by 10 feet, and have six-inch bars with a travel of 10 feet. The machines back of the one upon which the three-pounder is fixed are boring recoil slides for three-inch 50-caliber guns. A semi-automatic gun, it may be of interest to mention, is intermediate between a rapid-fire gun and an automatic gun; like both the others, it uses fixed ammunition, but the cartridge is loaded in by hand instead of being fed in automatically; the recoil of the gun, however, automatically opens the breech block and extracts the empty cartridge case. The rate of fire is about 30 to the minute, as against 25 to the minute for the rapid-fire gun, and about 50 shots per minute for the one-pounder automatic.

Aluminum was first produced from its ores in 1827, Frederick Wohler, of Germany, having discovered the process.

Patent Assignments

By William C. Terry

It is a curious but well demonstrated fact that people who have inventive genius often lack the means to carry out their ideas. The inexperienced patentee is apt to make the fatal mistake of assigning to another an undivided interest in his invention.

In an assignment of an undivided interest the assignee is afforded an opportunity of manufacturing, using and selling to others the article covered by the patent; and can proceed with the patent in much the same way as if he were the sole owner. Such an assignment may appear well enough on the face of it, and many patentees have been misled, supposing the proceeds from the patent should be divided *pro rata*, according to the several interests. This, however, is not the case in such assignments, and joint ownership of a patent, or interest therein, does not of itself, without an express agreement to that effect, make the parties partners. They are merely tenants in common, each having the right to separately make, use, or sell the invention so assigned, without liability to account to their co-owners for any part of the profits derived from the invention through their own efforts.

Abstract of Decisions Relating to Assignments

An assignment made before the patent was granted is valid.

An invention may be sold and assigned as well before application for a patent as afterward.

When an assignment is made pending an application for letters patent, it is fair to assume that the parties contract with reference to the legal title which they expect will be granted.

As a general rule, an assignment of an interest in a patent must be in writing, for the reason that such transactions are required to be recorded, and in fact and reality are not authorized to be made in any other way.

The assignment of a patent in whole or in part is authorized by Congress, and is required to be recorded in the patent office. After an assignment has been recorded, a duly authenticated copy of it is *prima facie* evidence at least.

If the inventor purposely limits the scope of the claim, the assignee cannot obtain a reissue for anything broader than claimed by the inventor.

It would not be policy to allow anyone but the one who is the owner of an undivided part of the entire invention to prosecute an application, owing to great confusion that would necessarily result.

Although an inventor sells his invention to another, who has also aided him in perfecting it by suggesting minor incidental improvements, the latter does not by these means become entitled to a patent as the inventor.

Steels Used in Automobile Construction

Analyses and Physical Characteristics of Carbon Chrome Nickel Steels and Other High Class Materials Used in Making Frames, Gears, etc.

BY E. F. LAKE

With the advent and improvement of the automobile, many new alloys of steel have been brought into general use, and some of these are the highest grades that are manufactured. This is due largely to the high power which is required, and with this high power, the weight, which is a very important factor, must be cut down to the lowest possible limit consistent with the strength required. For this, and other reasons, every automobile factory has its experimental department and testing laboratory in which all steels, as well as other materials, are analyzed and tested.

Extensive Tests and Analyses

These tests and analyses have been carried on to such an extent that the kinds of steels used for the different parts of the motor car are pretty well standardized, although new alloys of steel are being brought out continually, for which great claims are made. For that reason, any rules laid down are subject to modifications and improvements, as great progress is being made in the making and using of special steels, at the present time.

Silicon, manganese, nickel, chromium, vanadium, tungsten, molybdenum, titanium, arsenic, aluminum, cobalt, boron, uranium, copper, tin, zinc, and platinum have been added to steel, in all kinds of combinations, to give it the desired qualities for special purposes, and their effects on the physical characteristics of the metal, under various thermal treatments, have been very carefully studied, especially by those engaged in the manufacture of automobiles.

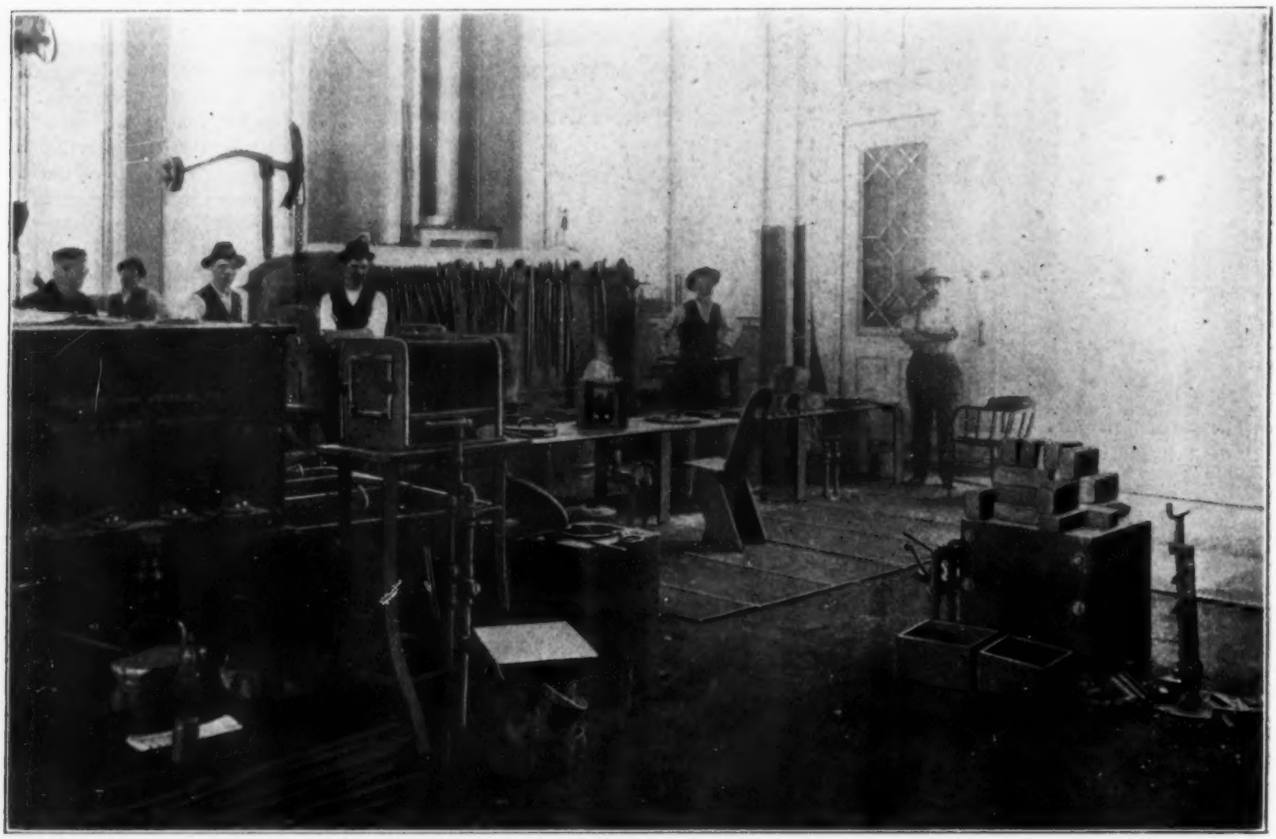


FIG. 58. SOME AMERICAN GAS FURNACES FOR CASE-HARDENING AND TEMPERING, AND A SMALL OPEN GAS FURNACE

High-grade Steel

The general characteristics usually specified for steels for automobile use are that they must be free from physical defects, such as scabs, seams, heavy scale, and surface defects; and that they must be sound. They are usually purchased on the basis of physical test and chemical analysis combined, and any shipment not up to the standard of these tests after a careful analysis, may be rejected. For these tests, two round, 7/8-inch bars are rolled, from every heat, and representing two separate ingots.

The steel generally used in the manufacture of high-grade cars, for the gears, such as differential, transmission, and driving gears, is a 0.45 per cent. carbon chrome-nickel steel of the following composition: Chromium, not less than 0.80 per cent.; nickel, not less than 1.50; carbon, 0.40 to 0.55; phosphorus, not over 0.04; manganese, not over 0.40; sulphur, not over 0.04 per cent.

Physical Characteristics

A specimen from the 7/8-inch round test bar, fully annealed, must show characteristics as follows: Tensile strength per square inch, not less than 90,000 pounds; elastic limit, per square inch, not less than 65,000 pounds; reduction of area, not less than 35 per cent.; elongation in 2 inches, not less than 18 per cent.

When heat-treated, that is, quenched in oil and partly annealed, this steel must show characteristics as follows: Tensile strength per square inch, not less than

180,000 pounds; elastic limit per square inch, not less than 140,000 pounds; reduction of area, not less than 20 per cent.; elongation in 2 inches, not less than 8 per cent.

This is considered the highest grade of steel, either foreign or domestic, in the market, and its strength, both annealed and heat-treated, puts it in a class by itself.

The Effect of Chromium

Steels containing chromium only are never used in automobile building, as chromium produces a mineral hardness. Hence other elements must be added to offset this quality and make the steel so it can be machined. Chromium, however, has a strong tendency to destroy the development of the crystalline structure, and therefore refines the grain and opposes itself to the occurrence of cracks, which may be produced by sudden strains. When alloyed with nickel it neutralizes the tendency toward cracking which all nickel steels have. The addition of chromium to nickel steel to a large extent overcomes the tendency toward lamination, and increases the elastic limit to figures which a few years ago would have been considered impossible.

Machining Chrome-nickel Steel

This steel cuts with some difficulty, but if properly annealed (and it should be furnished by the steel makers in that condition) it can be machined, with a high-speed tool, at the rate of 35 feet per minute, with a 1/16-inch feed, and a cut 3/16 inch deep. If the steel is in a harder condition than this it has not been properly annealed.

FIG. 60. ONE OF THE LARGE GAS FURNACES FOR FORGE AND WELD HEATS

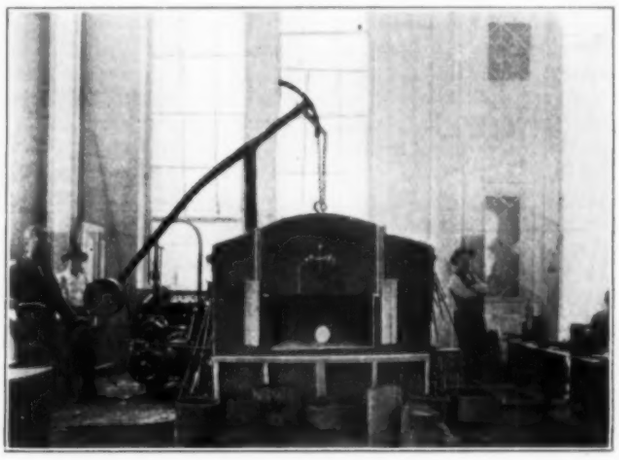


FIG. 61. LARGE CLOSED FURNACE FOR CASE-HARDENING AND ANNEALING

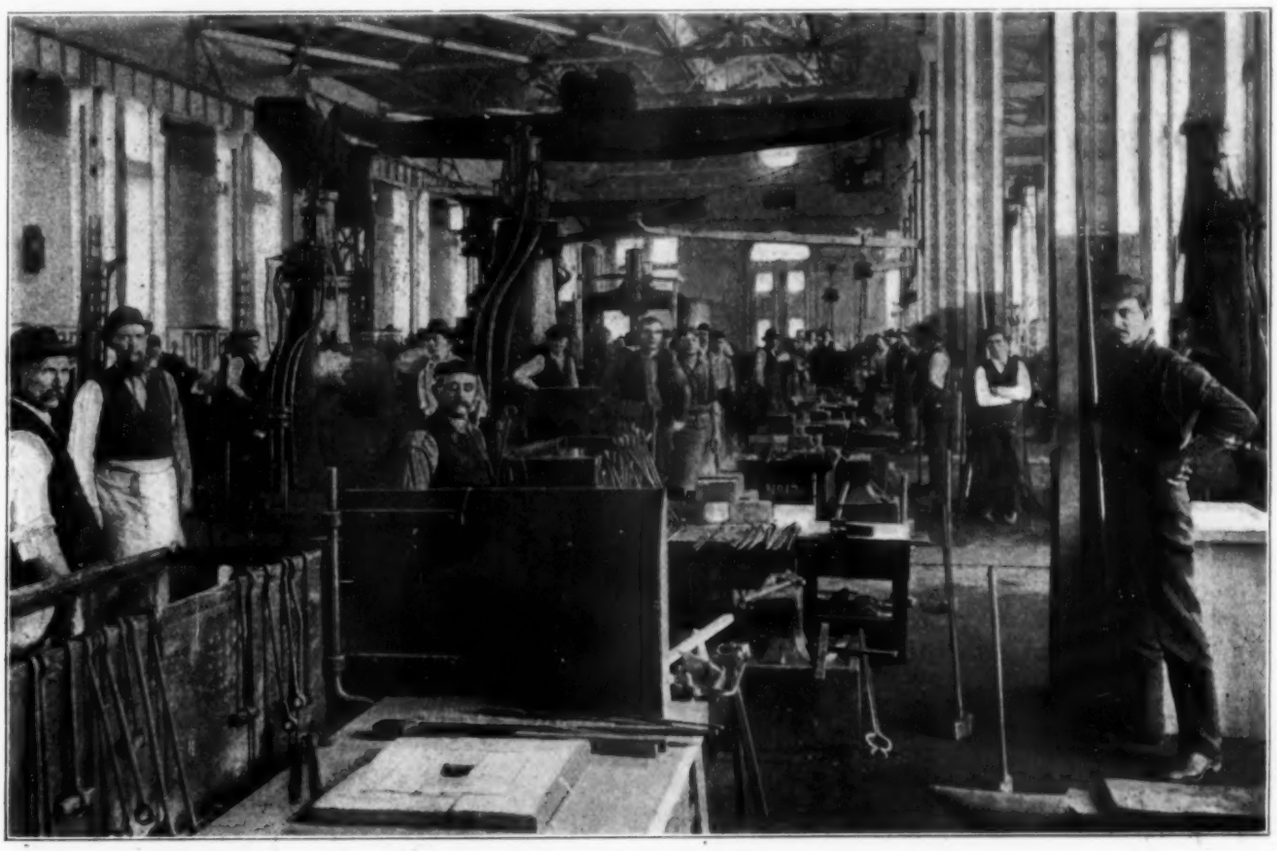


FIG. 59. INTERIOR OF FORGE SHOP, SHOWING OPEN FORGES, ETC.

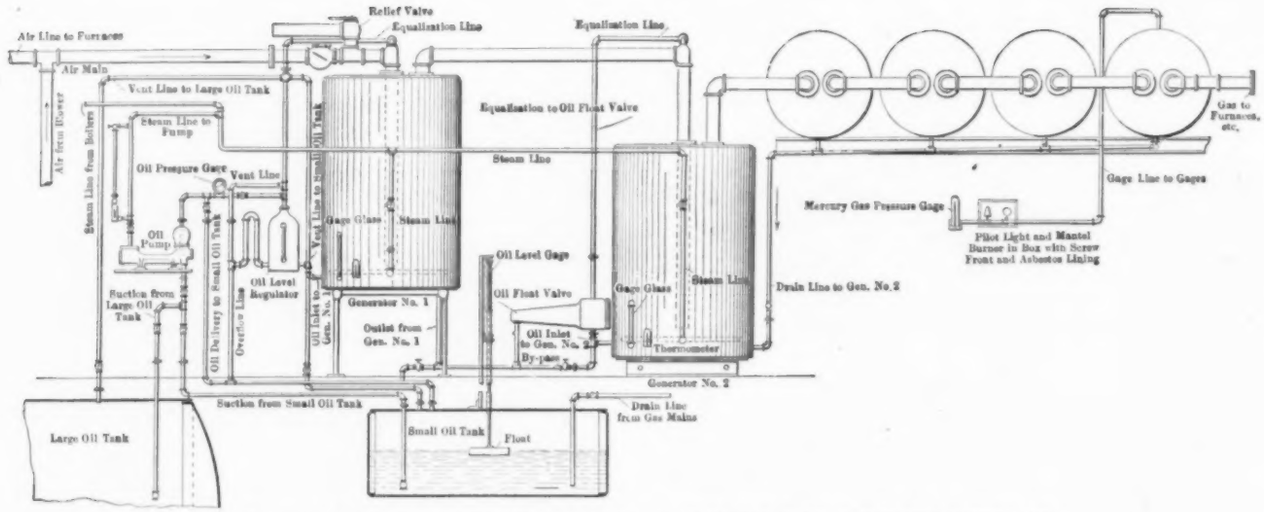


FIG. 63. DIAGRAM SHOWING APPARATUS FOR GENERATING GAS FROM PETROLEUM DISTILLATE

So much, however, depends on the handling and treatment of this steel, that the mere fact that it is being used by a manufacturer does not mean that any better results will be obtained than by the use of even good carbon steel. However, if properly handled, the results shown are remarkable.

Annealing and Heat Treatment

In annealing, the operation is different from that followed with ordinary steels. The material should be heated to a temperature of 1400 degrees Fahrenheit, and held as near to that point as possible for from four to five hours, after which it should be allowed to cool slowly by packing in charcoal or in a slowly cooling furnace.

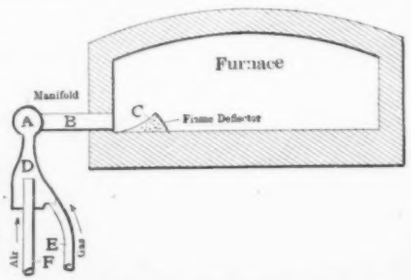


FIG. 62. DIAGRAM SHOWING METHOD OF BURNING THE GAS

In heat-treating it should be heated to about 1500 degrees Fahrenheit, and made as hard as it can be by quenching in oil or water, and then, to relieve the internal strains, it should be drawn in oil at from 400 to 600 degrees Fahrenheit; 500 degrees is preferred.

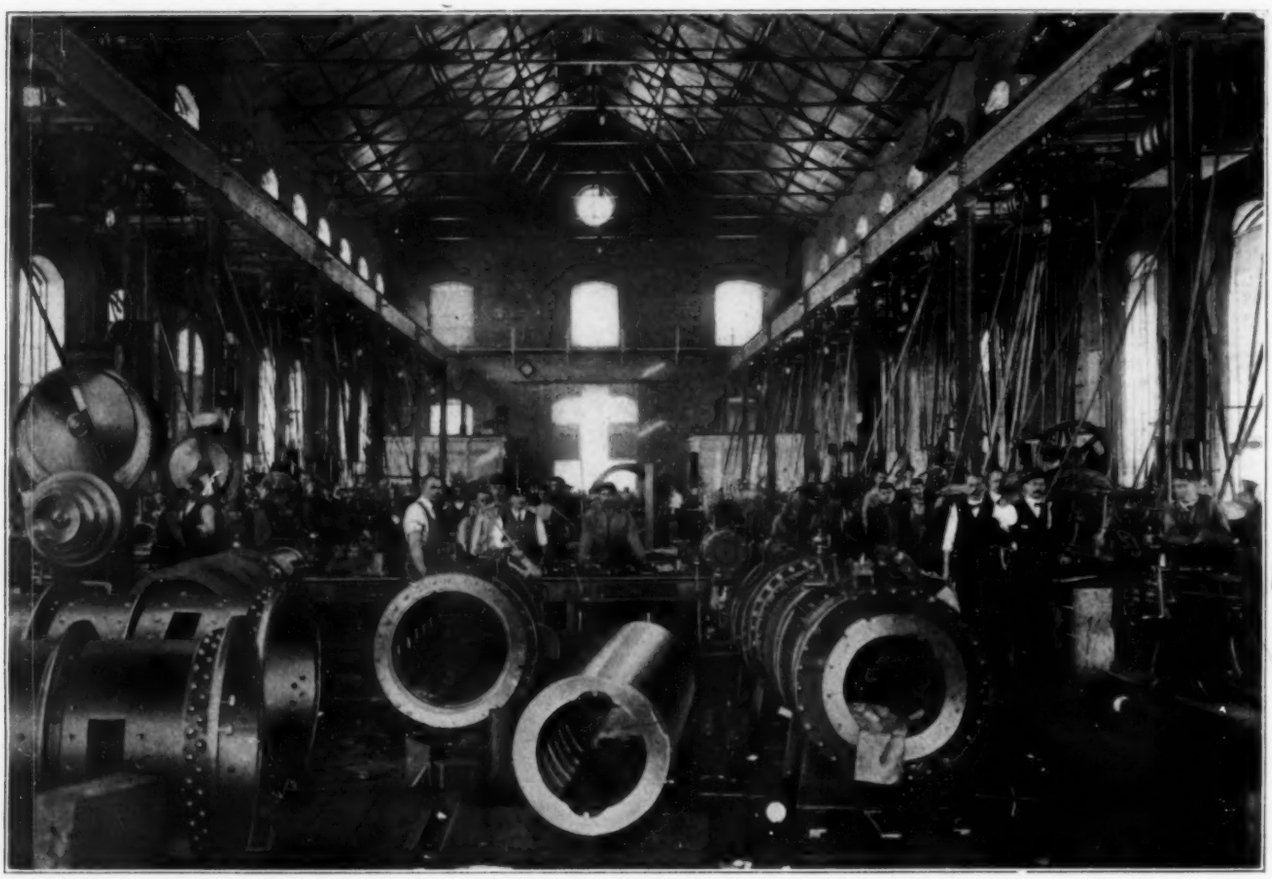


FIG. 64. SECONDARY MOUNT SHOP

If treated in this way it is the best material on the market, today, for gears, as it is hard enough to resist wear, tough enough to resist shock, and stronger than any other material of a similar hardness and toughness. It will resist the action of a file and it is very hard to break a tooth from it even with a sledge hammer.

By carrying the annealing operation farther, the metal is made more ductile, but less hard, up to 1150 degrees Fahrenheit; at this point it reaches the maximum of strength and ductility combined, but it is a little too soft to make the best wearing gear.

Carbonization

Opinion differs, however, as to this steel's becoming hard enough for transmission gears by being quenched in oil, and for that reason some think it is necessary to carbonize it, so as to get enough surface hardness. This carbonizing should be carefully done, and must be followed by a special treatment. Most steels when heated above 1250 degrees Fahrenheit, in intimate contact with nitrogen-carbon compounds, absorb carbon slowly. The external metallic layers, to a certain depth, depend upon time and temperature to be come more highly carbonized. The degree of carbonization of the skin depends, mainly, on the temperature, while the depth is dependent more upon the time during which the metal is exposed to the carbonizing influence. After carbonizing, positive quenching produces a hardened surface, while the body of the metal below the carbonized skin acts independently of it.

Treatment of Gears

The gears, after being machined and made ready for carbonizing, should be placed in a mixture of bone and powdered charcoal, and after being carefully packed in the carbonizing mixture should have the temperature raised to a point a little below that which would melt the cast-iron pots in which the gears are packed. They should be kept at this temperature for at least four hours, after which they should be allowed to cool in the pots and mixture in which they are packed, and must not be uncovered until perfectly cool, as this would reduce the internal strains, and consequently the gears would become distorted and warped. After they are entirely cooled they should be taken out and heated to a temperature of 1400 degrees Fahrenheit, kept at that temperature for three or four hours, and then allowed to cool slowly, as this annealing is necessary to break up the coarse grain produced by the carbonizing temperature. After this annealing the work can be heat-treated for hardening, as described above.

Drop Forging

This steel can be drop forged, but not as easily as common steel or nickel steel, as there is great danger in hammering it after its temperature has dropped below a bright yellow. If it is to be drop forged, the steps between the different dies should be shorter—that is, there should be less change between the die forms than is usual with common carbon steels.

Commercial Specifications

The specifications of this steel, as to analysis and physical properties, are not based on theories and speculation as to what should be, but are based on what it is commercially possible to obtain at prices that are not prohibitive; and, therefore, some steelmakers may be able to show figures that will prove that they can beat the specifications here demanded, as, for instance, phosphorus is given at not over 0.04 per cent., which is higher than it should be, as 0.015 per cent. is much better if obtainable. No matter what the composition of the steel may be otherwise, if the phosphorus is too high it is nearly useless, owing to its making the steel cold-short, treacherous and not capable of resisting any reasonable shocks.

Importance of the Shock Test

Steel that is very good otherwise, but too high in phosphorus, may show tests that are perfectly satisfactory as regards tensile strength, elastic limit, elongation and contraction, and may hold the right percentages of the components proper for use; yet a shock test may show that it is not fit for use. For this reason, after all the other tests have been made, the steel should be given a shock test under a suitable drop hammer.

One System of Grading

For this reason, also, some motor-car builders recommend that steel should be graded according to the phosphorus it contains, as in the following table:

Per Cent. of Phosphorus.	Grade of Steel.	Price per Lb.
0.10	Useless.	1½c.
0.075	But little better.	2c.
0.05	Just fair.	3c.
0.03	Good.	5c.
0.02	Very good.	8c.
0.01	Extra good.	15c.

This, however, is carrying a point to the extreme, and is more theoretical than practical, as the steels with 0.01 per cent. of phosphorus are almost unknown and those of less than 0.03 per cent. are anything but common. Then, again, to get the phosphorus very low, other components which are essential to the making of very high-grade steels would have to be sacrificed.

A Remarkable Racing Frame

Where cost is not a factor this steel has been used for making crank shafts, frames, etc. In the case of one of the Vanderbilt cup racers, the side members of the frames were ∩ shaped, 5¾ inches wide for a distance of 34 inches in the center and tapered down to 3½ inches wide at the rear end, and 3 inches at the front end. These were of 16-gage metal, which is 1/16 inch thick. The two end cross members were 3 inches wide and of 14 gage, while the two middle cross members were angle steel of 11 gage, or about ⅛ inch thick. This entire frame weighed but 135 pounds, and carried a 120-horsepower engine, which, with the accessories, seats, driver, and mechanic, would weigh in the neighborhood of one ton. This frame stood the tremendous strains and stresses that it was subjected to by the high speed and rough roads, without being injured in any way, and the fact that it did not double up or buckle seems remarkable.

Comparative Tests

One of the tests made before the frame was built was to take two pieces of the

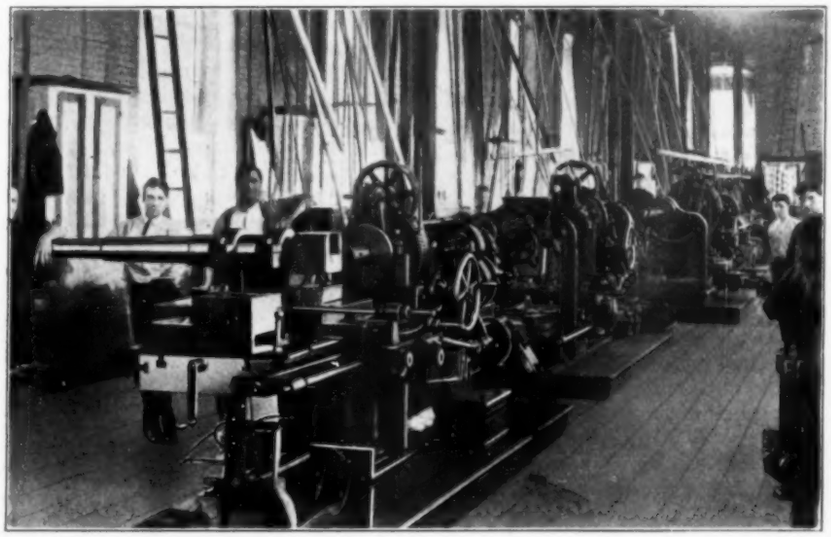


FIG. 65. SECONDARY-MOUNT SHOP; THREE-POUNDER GUN ON MACHINE

same size and shape, one of common carbon steel, and the other of chrome-nickel steel, and grip them in a special machine. The free ends were so loaded that when revolved they were bent alternately in opposite directions until broken. The carbon steel went 200,000 revolutions, while it took 45,000,000 revolutions to fracture the chrome-nickel steel.

Further Tests

Other tests, of a similar nature, have been made by the different manufacturers, with practically the same results, and these prove conclusively that this steel is far superior to the other steels for withstanding repeated stresses. It has also been bent at right angles, while cold, without showing the least signs of cracks or seams, showing that it is possible to press it into frames cold and treat it afterward, if desired. One of the large firms that manufacture frames is now building them of chrome-nickel steel.

This high-carbon steel, however, is generally used for making the gears only, as it is not easily forged, and a lower-carbon, chrome-nickel steel is used for such parts as crank shafts, transmission shafts, propeller shafts, sprocket shafts, rear axles, wheel pivots, axles, or in other words all the important parts of an automobile.

25 Per Cent. Carbon Chrome-nickel Steel

The specifications for this material, called 25 per cent. carbon chrome-nickel steel, are the same as the first specification, except as regards carbon, and are therefore as follows: Chromium not less than 0.80 per cent.; nickel, not less than 1.50 per cent.; carbon from 0.20 to 0.35 per cent., 0.25 per cent. preferred; phosphorous not over 0.04 per cent.; manganese, not over 0.40 per cent.; sulphur, not over 0.04 per cent.

A ⅞-inch round bar, fully annealed, must show the following characteristics: Tensile strength, per square inch, not less than 85,000 pounds; elastic limit, per square inch, not less than 65,000 pounds; reduction in area, not less than 50 per cent.; elongation in 2 inches, not less than 20 per cent. When heat-treated by the steelmaker, that is, quenched in oil and partly annealed, it must show the following characteristics: Tensile strength, per square inch, not less than 130,000 pounds; elastic limit, per square inch, not less than 100,000 pounds; reduction in area, not less than 30 per cent.; elongation in 2 inches, not less than 12 per cent.

Speed of Working

When thoroughly annealed this steel should cut at the rate of 35 feet per minute, with a 1/16-inch feed, 3/16 inch depth of cut, by using a high-speed tool. If it does not, it has not been properly annealed.

These specifications are placed at limits that will fully protect the buyer from an inferior steel, and at the same time make it commercially possible for the steelmaker to deliver the goods without any extra cost or trouble.

Application in Automobile Construction

This steel is used by many automobile builders for gears, although it does not become as hard as the first one when quenched in oil; but hardened in oil at 1500 degrees Fahrenheit it is quite hard and far superior for the purpose to any other grade of steel on the market. Vanadium steel is the nearest approach to it, but this is a new steel which has not been thoroughly tested as yet.

For all work that needs case-hardening the instructions that were given for the first steel should be followed as nearly as possible, as the best results can be obtained only by observing those rules; and they cannot be followed as closely as is necessary unless a pyrometer is used to measure the heat.

Heat Measurement

The best practice in this respect seems to be the use of a thermo-couple, consisting of platinum wires twisted together with platinum-iridium or platinum-rhodium wire, and measuring the current by the milli-volt meter or a special galvanometer, for these high temperature measurements. Care must be observed in the use of this instrument, and a certain amount of knowledge is necessary for its successful operation, as the unskilled man is liable to destroy its effectiveness.

It may seem a saving of time, and easier, to quench this metal immediately after it comes from the carbonizing pot; but this is bad practice, as it leaves the steel in a brittle and coarse-grained condition.

Forging

This steel forges more easily than the first one, and for that reason is better adapted to the manufacture of crank shafts than the other. Owing to the tremendous stresses that are put upon the crank shaft in an explosion engine, it is essential that they be forged; and hammer forging is the best process, as the metal gets a more thorough working and greater homogeneity of the material is assured. The usual method employed is to take a large ingot, place it under a powerful press, and forge it into a billet by reducing it to about 1/20 of its original sectional area, as by this thorough working through of the metal great density of grain is secured, and unsound places of any sort are rendered impossible. By causing a light hammer to descend on the work at a high speed, only the surface is bruised. The drop-forging hammer also has a tendency to produce this bruising effect.

Inspection of the Billet

The billet is then carefully examined over its entire surface and at both ends, to discover any "piping" that may occur. For this purpose, new fractures are made at both ends, so that it may be examined more closely. Nickel steel is liable to show these "pipes" or "seams," as well as other imperfections, but where chromium is added it offsets this tendency of the nickel by making the metal more adhesive and tougher.

After the billet has been examined, it is reduced to the proper size and shape for machining into the crank shaft by hammering. The influences of the skin and other superficial inequalities are removed.

Further Operations and Tests

The billet is skinned, rough turned, planed, etc., after which it is examined for any fractures which might appear, and then it undergoes the processes of hardening and annealing to remove any internal strains which may be there. The results of this process are then tested, by tensile tests, to ascertain the physical properties; by bending tests, to ascertain its toughness, and by hardness tests, to ascertain if the piece throughout is of equal toughness and absolutely uniform in quality. After this it is finished by turning, milling, or planing, and grinding, in machines made specially for this purpose. It is also good practice to pickle all forgings, as this removes the crust and makes it a great deal easier to detect any flaws which may occur.

A Foreign Steel

Some motor-car builders are using a foreign steel for forgings that have to withstand severe alternating shock loads, such as the differential shafts, transmission parts, universal joints, axles, etc. The composition of this steel is: Chromium, 1.50 per cent.; nickel, 3.50; carbon, 0.25; silicon, 0.25; phosphorus, 0.015; manganese, 0.40; sulphur, 0.025 per cent.

The physical properties of this steel are: Tensile strength, 120,000 pounds; elastic limit, 105,000 pounds; reduction in area, 58 per cent.; elongation in 2 inches, 20 per cent.

Characteristics

This steel forges readily without diminishing the elongation below a safe limit, and its notable features are its low percentage of phosphorus, which is an important point to consider in the selection of steel for motor-car work, as well as a low sulphur content, which is the second point that should be looked after. It is not very difficult to get a high tensile strength, but the quality of reliability may be lost after heating and forging.

Owing to this steel's being imported, its price is higher than the domestic steels, and the results obtained do not warrant paying the difference in price, as the American steelmakers can get the phos-

phorus and sulphur much below the 0.04 per cent. given in the specifications of the first two steels described; and when this is brought to, or below, 0.025 per cent. there is no better steel made at the present time.

Nickel Steel

The next or third grade of American steel used by the automobile manufacturer is a nickel steel of the following composition; Nickel, not less than 1.50 per cent.; carbon, from 0.25 to 0.35, 0.30 desired; phosphorus, 0.03; manganese, 0.60; sulphur, 0.04 per cent.

This must show the following physical characteristics, when fully annealed and tested from a piece of the ⅞-inch round bar: Tensile strength, per square inch, not less than 85,000 pounds; elastic limit, per square inch, not less than 60,000 pounds; reduction in area, not less than 50 per cent.; elongation in 2 inches not less than 25 per cent.

When heat-treated, that is, quenched in oil and partly annealed, it must show the following physical characteristics: Tensile strength, per square inch, not less than 100,000 pounds; elastic limit, per square inch, not less than 70,000 pounds; reduction in area, not less than 50 per cent.; elongation in 2 inches, not less than 20 per cent.

Use in Medium- and Low-priced Machines

This is a grade of steel that is substituted for others, in the medium- and low-priced automobiles, as the approximate price of the nickel-chrome steel is 15 cents per pound, while the price of the nickel steel is about 10 cents per pound. In addition to this, there is the extra labor of machining and working the nickel-chrome steel, which makes it more than double as costly as the nickel steel.

Nickel steel, as well as all other alloyed steels, should be handled with care, for if not the unexpected is liable to happen. For instance, nickel may be added to steel up to 35 per cent., with good results, but all the percentages of nickel between this and nothing will not give good results.

Comparative Merits

A careful examination of the specifications, in the tables given, will show the comparative merits of nickel and nickel-chrome steels, and that the results obtained will not be as good with the former as with the nickel-chrome steel, as far as strength and toughness are concerned. This steel, however, gives a great deal better results than any carbon steel, and is a great advance over such material. If properly carbonized it makes good gears for bevel drive, and differential or transmission gears, and if properly heat-treated good crank shafts, propeller shafts, axles, etc., can be made of it. Experience has demonstrated that axles, wheel pivots, and other parts, that have given away when made of carbon steel or any other material except nickel-chrome steel, have given good satisfaction if made of nickel steel and properly heat-treated or carbonized.

Difficulty with Local Hardening

If nickel steel is high in carbon it will not stand local hardening very well, but oil tempering can be done without difficulty. To illustrate, an attempt was made to harden the thrust end of a differential shaft, which contained 3.5 per cent. of nickel and 0.4 per cent. of carbon, and it was found that this could not be done with any degree of safety.

Faults Due to Improper Rolling and Forging

A surface defect in the bloom is said to show up somewhere in the finished product, and much talk is heard about its often being defective and cracking badly, but these faults are almost always caused, either by the rolling operations in the steel mill not being done properly, or in the forging done by the automobile builders after receiving the steel. In forging, nickel steel should be worked at a good full forging heat and kept at this heat while it is being hammered, pressed, or rolled. If this is done, cracks rarely develop and what few rejections are necessary, under proper working conditions, are more than made up for by the extra good qualities of the steel.

The qualities of this steel are so good that many selling agents of automobiles are claiming that the working parts of their cars are made of nickel-chrome steel when there is not a trace of chromium in it. This is due to the well known superiority of nickel-chrome steel over all others.

Shock Tests at the Krupp Works

The following shock tests were made by the Krupp steel works of Germany, and they coincide with others which have been made in this country:

Kind of steel.	Deflection by Shock in Inches				
	1	2	3	4	5
Nickel-chrome.	0.71	1.30	1.89	2.40	2.80
Nickel-chrome.	0.83	1.54	2.17	2.76	3.03
Nickel steel..	1.26	2.24	3.03	3.58	3.82
Carbon steel..	1.38	2.44	3.23	3.70	3.94

These tests were made with pieces 1.18x 1.18x11.81 inches. The distance between supports was 9.45 inches. The weight of the hammer was 448 pounds, and the hight of the fall of the hammer was 39.37 inches.

"Gun-barrel" Steel

The fourth grade of steel which is used is usually of the following composition: Carbon, from 0.45 to 0.55 per cent.; phosphorus, from 0.05 to 0.065 per cent.; manganese, from 1.10 to 1.30 per cent.; sulphur, from 0.00 to .06 per cent. A ⅞-inch round rolled test bar must show the following physical characteristics: Tensile strength per square inch, not less than 85,000 pounds; elastic limit per square inch, not less than 55,000 pounds; reduction in area not less than 45 per cent.; elongation in 2 inches not less than 15 per cent.

This steel is not of the usual composition, being high in carbon and very high in manganese, and it should be bought only from those steel makers who thoroughly understand the rolling and hammering of it, as it is very easily spoiled by poor methods of working.

This is what is known as "gun-barrel" steel by the trade, and has been used extensively by the U. S. Government in the manufacture of rifle barrels, in which are used the high-pressure smokeless powders.

Welding Carbon Steel

This steel is not weldable, as it is so high in carbon that it cannot be raised to a welding heat without burning. Steels as low in carbon as 0.15 per cent. are susceptible to heat and must be handled very carefully in welding; while steel of 0.20 per cent. carbon becomes entirely unreliable when subjected to a cementing temperature, and steel containing 0.5 per cent. carbon is wholly unmanageable at considerably below the welding temperature. While other components of steel are to be taken into consideration when welding, the fact still remains that carbon is the main drawback. Low-carbon steels are weldable, but they are never as strong at the weld as at the unwelded sections; hence the piece is usually made of larger section, where the weld is to occur, than is necessary in the unwelded sections.

Roll and Hammer at a Low Heat

This steel should be rolled and hammered at a low red heat, and if this is properly done a greater strength can be obtained than is given by the figures in the table. It should be used as received from the steel makers, owing to the added strength given to it by rolling and hammering which will be lost if the steel is re-heated to any appreciable temperature.

"Gun-barrel" Steel for Auto Parts

The price of this steel runs from 5 to 6 cents per pound, and, where the selling price of an automobile is so low that it does not allow the expenditure of 10 or 15 cents a pound for any large quantity of steel to enter into its construction, this steel may be and is substituted for such parts as shafts, axles, etc., without heat-treating, as it has been found by experiments and experience to be very capable of resisting the alternate stresses that are met by axles and other similar parts.

On the higher-priced cars it is used for parts that require considerable stiffness and strength, and at the same time do not require the extraordinary strengths of the higher grades of steel; for instance, such parts as steering arms, lamp brackets, fender irons, brake levers, etc. If bought

in large quantities it may be purchased for less than the five cents quoted above.

Low-carbon Steel

The next or fifth grade of steel is known as low-carbon steel and has the following composition: Carbon, from 0.28 to 0.36 per cent.; phosphorus, not over 0.05 per cent.; manganese, 0.30 to 0.60 per cent.; sulphur, not over 0.06 per cent. It must show the following physical characteristics, when tested with a ⅞-inch round, rolled, test bar: Tensile strength, per square inch, not less than 75,000 pounds; elastic limit, per square inch, not less than 40,000 pounds; reduction in area, not less than 40 per cent.; elongation in 2 inches, not less than 25 per cent.

This is merely a high grade of machine steel and is used for such parts as do not require any special strength.

Machining and Case-hardening

It can be machined readily, is forged with good results and can be case-hardened well. In case-hardening it should be carbonized, cooled slowly before uncovering the carbonizing pot, and then reheated and quenched in oil or water, whichever gives the proper hardness for any given part. In other words the same treatment for case-hardening should be followed as was described in detail for the nickel-chrome steels.

This makes a good steel for ball-bearing cases and cones to be hardened, and is used largely for such parts as foot pedals, steering rods, etc.

Spring Steel

The sixth grade of steel used is known as spring steel, and the following composition is the best for automobile work: Carbon, from 0.85 to 1 per cent.; manganese from 0.25 to 0.50 per cent.; phosphorus, not over 0.03 per cent.; sulphur, not over 0.03 per cent.

This steel, as the name implies, is used for springs only; and, owing to the part which they have to perform and the peculiar stresses which are put upon them, the steel must be of a different nature and composition from that used for other parts. Before the advent of the automobile, springs were usually made of a cheap grade of bessemer stock; the U. S. Government, however, and the Pennsylvania Railroad Company demanded a better grade of steel for their springs. The requirements of the automobile are such that they also need a better grade of springs.

Automobile Springs

The flexibility must be as high as possible in order to absorb the shocks that the automobile gets from the uneven surfaces of a country road, while traveling at a high rate of speed.

The springs must also be strong enough to carry a given load without breaking or becoming deformed, and at the same time they must be as light as possible.

Springs are of such a nature that they should have an exceptional resistance to shock in a longitudinal plane, but very little is needed at right angles thereto. Therefore, the leaves of a spring should be rolled to shape as closely as possible, and hammered as little as possible, in order to preserve the longitudinal grain in the stock as it comes from the steel mill, caused by the rolling. For this reason some add silicon to their spring steel, owing to the extremely fibrous property that it imparts to the metal.

This steel should be handled only by reliable spring makers, in order to get the best results, and if this is done there will not be as many accidents from broken springs as there have been in the past.

Valve Metal

One other alloy of steel used by nearly all motor-car builders is commonly called valve metal as it is very seldom used for any other purpose. Its composition is as follows: Nickel, 30. per cent.; carbon, 0.50; phosphorus, not over 0.04; manganese, not over 1.50; sulphur, not over 0.06 per cent.

Pure nickel is seldom used for valves, at present; the above has been substituted as it is stronger, wears better, and has plenty of heat-resisting qualities for the combustion engine, although it is not as good in this respect as the pure nickel.

Nickel-chrome Compositions

In conclusion it would be well to add that in the nickel-chrome steels many different compositions have been tried, but the specifications here given will show as good results and as satisfactory tests as any of the different compositions offered, while they are much better than most nickel-chrome steels.

The automobile industry has given an added impetus to investigation and scientific research into the qualities of steel, and the different elements which may be added to it to produce desired results. No rules which may be laid down can be considered permanent or positive, owing to the many new combinations which are being brought out from day to day.

Strong Materials

With the nickel-chrome steels as specified in this article, test bars can be obtained from the steel makers that will give a tensile strength as high as 225,000 pounds per square inch, or possibly 250,000 pounds and elastic limits of 175,000 pounds per square inch, or possibly 225,000 pounds; but in the tables I have given only such figures as can reasonably be guaranteed by the steel makers. The same statements hold good as to the nickel, carbon, spring, and valve steels. It is also possible to get all of these steels with a much lower percentage of phosphorus and sulphur than that given in the tables, which should by all means be done where it is possible. There is no doubt that new products will be brought out in the future which will give even better results than have been obtained up to the present, as the exacting demands of the automobile have led to scientific progress in metallurgy.

The Professional Educator and Trade Schools

By Wilbert S. Drew

There is in this country an increasing and, to my mind, a most happy tendency to make a sharp distinction between manual training and trade schools. Having had considerable experience with both classes of schools, I am impelled to add to the discussion of them, so ably started by Entropy, at page 238, because, in my opinion, the Massachusetts Industrial Education Commission will miss the main purpose of its creation, if it does not devote its energies chiefly to the promotion of trade schools.

Let us review, as briefly as possible, the contrasting conditions of these two classes of schools. In the average manual training high school, the hand work is merely tacked on in addition to the regular academic work of an already crowded curriculum. Also, each graduate has done work in all the shops of the school, the object being to secure intellectual breadth rather than to produce mechanics. These conditions are quite sufficient to prevent such schools from ever teaching any trade thoroughly, though they might do much more in that direction than they generally do, were it not for the class of teachers usually employed.

The character of the teaching force is the main difficulty of this kind of schools, indeed, of every kind for that matter. The principal is almost always a man of academic training, who knows no trade and has little comprehension of the educational value of knowing one. The main qualification that such a man requires of a manual training teacher is that he be a graduate of some normal or technical school. Thus it comes to pass that the mechanical training of most of these teachers is only such as may be obtained in a school or college shop; and it is exceptional to find among them a man who could earn his living, outside of an educational institution, at the kind of work he is trying to teach. Worst of all, when the principal does know what sort of teacher he ought to have, he can offer no financial inducement that will be any attraction. Yesterday I received a letter from a teacher's agency, asking me to recommend candidates for manual training positions paying from $800 to $1500. Needless to say, I did not reply. Until all kinds of institutions for industrial education are prepared to pay salaries on a par with equally responsible commercial posi-

tions, they cannot expect to attract the kind of men they need from the strenuous business competition of our time.

Trade-school conditions are widely different from those above described. The pupil works at only one trade throughout his course, and spends at least half of his school time in the shop, while such academic work as he has time for is selected with direct reference to his trade. Thus his hand work gets all the emphasis; and, when he has completed his course, he is ready to earn his living by working at a trade, a thing seldom true of a manual training graduate.

A trade-school principal should always be a man of broad intellectual attainments and wide commercial experience, thoroughly conversant with the needs and conditions of commercial shops. He should know at least one trade thoroughly and enough of all the others taught in his school to judge whether his teachers are doing good work. Such a principal will never employ, to teach a trade, a man who does not know that trade thoroughly, whether he knows anything else or not. But he must know something else, and the trade school's main difficulty is also with its teaching force.

It is not so easy as one might think to find a man who knows the theory and practice of his trade well enough to teach it and who also speaks tolerable English and has a good influence in the school. Moreover, when this rare specimen is found, he must be paid at least as much as he can earn at his trade to induce him to become a teacher. My experience does not lead me to have any faith in Entropy's suggestion that such a man can be induced to make any personal sacrifice for the love of the work. On the contrary, I think the salary which the community must learn to pay for a good teacher, where commercial competition enters in, will eventually prove to be the lever on which the salaries of the whole academic teaching force will be raised.

The scheme of a two-year trade-school course for grammar school graduates who have not time, taste or ability for a full academic or technical training, I consider most excellent. The number of trades provided for in such a school should be limited only by the size and wealth of the community. Where only one group of trades can be offered, as is often the case, that group should be selected which is most closely allied with the principal industry of the community.

In conclusion, I wish to speak feelingly concerning the ability of grammar school graduates to profit by a good trade-school course, on the basis of my own experience. I have known many boys, whose education was limited to the eighth grade, who have learned to do most excellent work at the trades which they have chosen. This could only happen where their teachers really knew their respective trades. Doubtless there are people who cannot teach what they know, but no one has yet been discovered who can teach what he does not know. When all those interested in industrial education realize the full import of this important truth, there will be much improvement along many lines in this country.

A Handy Balancing Device

By Canada

I was in a large shop which devotes itself to the manufacture of heavy transmission machinery when I noticed a six-foot pulley being balanced on a mandrel which was so far from the horizontal that the eye ten yards distant could detect the deflection. My first thought was that some apprentice new to the job was responsible for such a state of affairs; but when I pointed it out to my friend the superintendent, who was with me, he went over and showed me that the ends of the mandrel, instead of resting on parallels, were between and on little steel wheels (Fig. 1). These wheels or rollers ran on carefully adjusted ball bearings (see Fig. 2), giving a minimum of friction. Each set was blocked up on anything handy until the rim of the pulley cleared the floor. The castings holding the rollers were rough all over outside, and it did not appear to matter whether they were used in a perfectly vertical position or not.

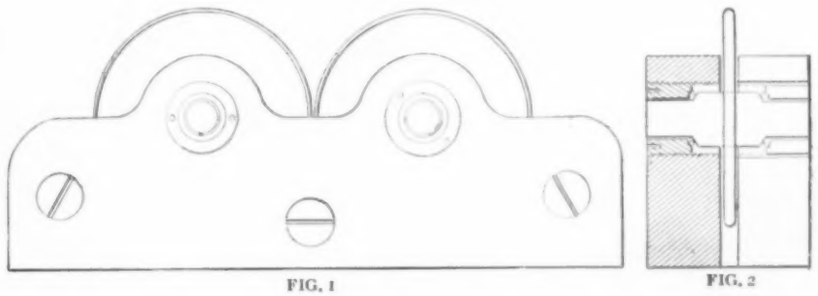


FIG. 1 FIG. 2

A HANDY BALANCING DEVICE

Handy in Repair Work

I expressed my surprise at such a method, but was assured that wheels balanced in this manner were as well done as by the ordinary method; and then I was told that these little instruments were very handy for all kinds of standing balancing. One instance cited was where the rim of a large solid pulley was broken straight across the face. The pulley was in the middle of a section of shafting laden with numerous other pulleys, etc., to remove which would have been an endless task. The rim was drilled with an electric portable drill and a piece of wrought iron riveted on the inside in the usual manner; then the coupling bolts were removed, and after the bearing caps had been loosened, a pair of these balancing rigs, placed about three feet from each coupling, were jacked until the whole shaft rested on them and turned heavy side down. It was then an easy matter to weight the pulley until the shaft was in balance.

These rigs are very handy for armatures, etc., where a part of the shaft is either tapered or of different size. A vane in a large blower was broken and it was found that it could be repaired in position. This was done, but after completion the balance was exceedingly "bum," as the boys say. The "rigs" were brought into play under the exposed parts of the shaft between the side and the bearings, with gratifying results.

A Government Experimental Shop

The Bureau of the Census of the Department of Commerce and Labor is developing an extensive machine shop for experimental purposes. In connection with plans for the shop, the bureau wishes to receive manufacturers' catalogs of small machinery, machine tools, and general supplies.

We have received a copy of the fourteenth Year Book of the Armour Institute of Technology, and also a pamphlet devoted to the evening classes conducted by the institute. The work of the institute has grown to large proportions, the total number of enrolled students, including those in evening and summer courses, being 1735. The work offered to evening students is very comprehensive and includes shop work, electricity, telephone engineering, fire protection, civil engineering, chemistry, mathematics, drawing and English.

According to the census, 57,513 persons in the United States suffered violent deaths in 1900, a large portion of them needlessly and heedlessly, while half a million more were injured. Where we have exact figures for comparison they show more than twice as many accidents in this country, relatively, as in Europe.

Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

Table for Setting Miller when Cutting Worm Wheels

The accompanying table gives the angles at which to set the milling-machine table for cutting worm wheels. This table will, I think, be of assistance to some of those engaged at the practical end of the business. It is the usual shop method to lay off the lines and then find the angle with the protractor. The table gets over this, as the diameters and threads can be used direct in finding the angle.

WM. CASEY.

Diameter of Worm on Pitch Circle in Inches.	Threads per Inch on Worm.									
	8	7	6	5	4	3	2½	2	1½	1
1	2°-16'	2°-36'	3°-2'	3°-39'	4°-33'	6°-5'	7°-18'			
1¼	1°-50'	2°-6'	2°-26'	2°-54'	3°-39'	4°-52'	5°-50'			
1½	1°-31'	1°-44'	2°-1'	2°-26'	3°-2'	4°-3'	4°-52'	6°-5'		
1¾	1°-18'	1°-30'	1°-44'	2°-6'	2°-36'	3°-28'	4°-12'	5°-12'		
2	1°-8'	1°-18'	1°-31'	1°-50'	2°-16'	3°-2'	3°-39'	4°-34'	6°-5'	
2¼	1°-1'	1°-9'	1°-21'	1°-37'	2°-1'	2°-41'	3°-15'	4°-2'	5°-22'	
2½	55'	1°-3'	1°-13'	1°-28'	1°-50'	2°-26'	2°-54'	3°-39'	4°-52'	7°-18'
2¾	50'	54'	1°-7'	1°-20'	1°-40'	2°-13'	2°-40'	3°-20'	4°-27'	6°-40'
3	46'	52'	1°-2'	1°-13'	1°-31'	2°-1'	2°-26'	3°-2'	4°-2'	6°-5'
3¼	42'	48'	56'	1°-7'	1°-24'	1°-52'	2°-14'	2°-48'	3°-44'	5°-36'
3½	39'	45'	52'	1°-3'	1°-18'	1°-44'	2°-6'	2°-36'	3°-28'	5°-12'
3¾	37'	42'	48'	59'	1°-13'	1°-37'	1°-57'	2°-26'	3°-15'	4°-52'
4	34'	39'	46'	55'	1°-8'	1°-31'	1°-50'	2°-16'	3°-2'	4°-34'
4¼	32'	37'	43'	51'	1°-4'	1°-25'	1°-42'	2°-8'	2°-51'	4°-16'
4½	30'	35'	40'	48'	1°-2'	1°-21'	1°-37'	2°-1'	2°-41'	4°-2'
4¾	29'	33'	38'	46'	58'	1°-17'	1°-33'	1°-56'	2°-35'	3°-52'
5	28'	31'	37'	44'	55'	1°-13'	1°-28'	1°-50'	2°-26'	3°-38'
5¼	26'	30'	35'	42'	52'	1°-9'	1°-23'	1°-44'	2°-19'	3°-28'
5½	25'	29'	33'	40'	50'	1°-7'	1°-20'	1°-40'	2°-15'	3°-20'
5¾	24'	27'	32'	38'	48'	1°-4'	1°-17'	1°-36'	2°-8'	3°-12'
6	23'	26'	30'	37'	46'	1°-2'	1°-13'	1°-31'	2°-1'	3°-2'
6¼	22'	25'	29'	35'	44'	59'	1°-11'	1°-28'	1°-57'	2°-54'
6½	21'	24'	28'	34'	42'	56'	1°-7'	1°-24'	1°-52'	2°-48'
6¾	20'	23'	27'	32'	40'	54'	1°-4'	1°-21'	1°-47'	2°-41'
7	19'	22'	26'	31'	39'	52'	1°-3'	1°-18'	1°-44'	2°-36'
7¼			25'	30'	38'	51'	1°-1'	1°-16'	1°-41'	2°-32'
7½			24'	29'	37'	48'	59'	1°-13'	1°-37'	2°-26'
7¾				28'	35'	47'	56'	1°-10'	1°-33'	2°-20'
8				28'	34'	46'	55'	1°-8'	1°-31'	2°-16'

ANGLES FOR SETTING MILLER TABLE FOR CUTTING WORM WHEELS.

Jig for Drilling Steam-pump Glands

Being a tool designer, I am much interested in the tools, jigs and fixtures appearing from time to time in your columns. I would like to submit a few criticisms in reference to the jig for drilling steam-pump glands, submitted by Syd. P. at page 84, which seems to me to be a poor design, and one in which the conditions for producing interchangeable work at small cost have received little consideration.

Referring to Fig. 1, page 84, the jig is simply a templet for locating the holes on the face of the gland, which is left to stand on its own base. This is of comparatively small diameter, allowing the line of pressure from the drill to overhang the base considerably, which causes a decided tendency for the whole affair to tilt. This in turn causes the drill to run off and bind, producing a poor job.

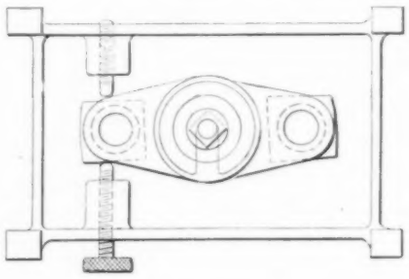
While Fig. 2 overcomes this defect, it must be, with a gland of any considerable size, a heavy, cumbersome and expensive affair, which requires a large amount of stock, together with a considerable amount of machining, and which, when completed, is heavy to handle and has too much base area in contact with the drill table to catch chips and dirt.

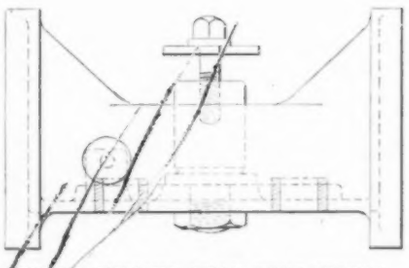
In designing jigs and fixtures for interchangeable work, it is important that the gage points should receive careful consideration, such points being selected as will be the least likely to introduce error in the result. In the present instance it will be safe to assume that the hole in the gland for the piston-rod will be of a standard size, with less variation than may occur in the turning of the body of the gland; it is therefore desirable, as is usually the case, to gage from the hole for all later operations. Since the face and back surface of the ears might, or might not, be finished, it would be advisable to slide the gland on to a shouldered stud, securing the same with cap screw and slotted washer to permit quick removal, locating the ear against the stop screw by means of a flat spring or thumb screw.

Fig. 1 herewith shows a cast-iron jig for drilling the gland required by your correspondent, which fully meets all conditions of interchangeable manufacture. It is of light and rigid construction, with large base area and with the line of pressure well within the base lines, allowing quick feed. There is no large area of base in direct contact with the drill platen to catch chips and dirt. The work is easily and quickly placed in position, while the construction is perfectly fool-proof.

In jigs of this class it is my practice to make the web ⅛ inch or 5/32 inch thick, well braced to resist the pressure of the cutting tools. It would be a large jig that would get a web 3/16 inch thick. The use of cast iron in jig construction permits the designer to produce a light, stiff and durable jig with the least amount of material, so distributed as to produce the greatest amount of stiffness to resist the stress of the cutting tools and clamping devices, combined with the least possible amount of machining in the construction of the jig itself.

I quite agree with your correspondent that *one* of the aims of jig design is "to





JIG FOR DRILLING STEAM-PUMP GLANDS

make them so that any blithering idiot may use them and not go wrong;" yet there are many other equally important things to consider, among which may be mentioned lightness, stability and quickness in handling, combined with accuracy of production within the required limits. As a general thing, excepting perhaps simple cases where little more than a templet is required, I do not favor built-up jigs of machine steel, for as a rule they are awkward and expensive and generally unsatisfactory, eventually finding

their way to the scrap heap to be replaced by the better designed, up-to-date cast jig.

H. D. PENNEY.

Details of Trolleys Running on I-Beams

At page 745, Vol. 29, Part 2, there is an article on I-beam trolleys, in which the correspondent points out the inadvisability of using conical rollers or wheels. His objection is that, because one end of the wheels is of smaller diameter that the other, slipping occurs; but I think this is so slight that it can be ignored for all practical purposes. Its chief drawback in my opinion is the thrust it puts on the plates. This is negligible except when the plates are rather small in width. In this case, if the plates are not made thick enough, they will open out.

The method of arriving at their strength is as follows: Draw the triangle of forces, drawing a line $A\,B$ (Fig. 1) at right angles to the flange of the beam. Set off to scale the load coming on one plate, which will be half the total load. This must be resolved into a thrust and a downward pressure on the plate. Draw a line $A\,C$ parallel to the plate from A, and a line at right angles to the plate from point B. Then $B\,C$ is the thrust and $A\,B$ the downward pressure. This thrust comes at the center of the wheeels, and the maximum bending movement on the plate is this thrust multiplied by the lever arm; i.e., the distance from the point of application of the load to the nearest support, which in this case is D.

The modulus of resistance of the section of the plate at $E\,F$ (Fig. 1) is next required. The thickness G (Fig. 2) is assumed and the modulus is 1/6 of $H\,G^2$, H being the effective width of the plate, the holes being deducted, and equals $J+K+L$. The bending moment is then divided by the modulus, which gives the fiber stress in tension and compression due to the thrust. In addition to this latter thrust, there is the downward pressure to be taken into account. This is obtained by dividing the total sectional area at the section $E\,F$ shown at Fig. 2 into the pressure, which gives the fiber stress, namely, tensional. But, as both the thrust and the tension are acting on the plate at the same time, this latter increases the tensional stress, and reduces the compressive stress due to the thrust, by an equal amount, and must therefore be added to the former and subtracted from the latter.

In steel plates, the tension and compression stresses must not exceed 15,000 pounds per square inch, and in cast iron, 2000 pounds in tension and 12,000 in compression. The foregoing comparatively low stresses are taken because such trolleys are subjected to jerks and rough usage.

The wheel shown in Fig. 3 is of a better design than either the conical or cylindrical type. This wheel has a semi-circular tread, and theoretically bears only on one point, thereby diminishing the friction be-

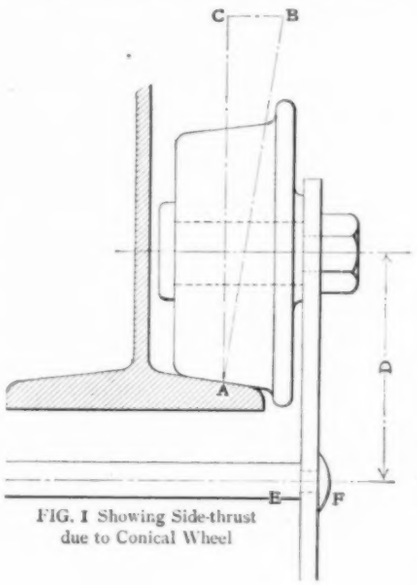


FIG. 1 Showing Side-thrust due to Conical Wheel

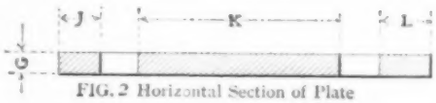


FIG. 2 Horizontal Section of Plate

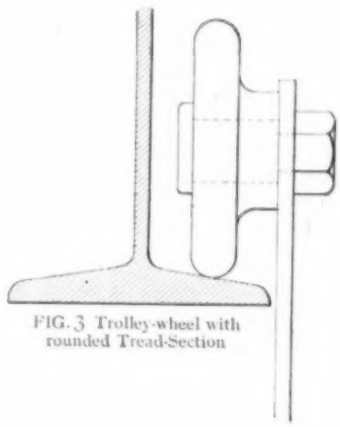


FIG. 3 Trolley-wheel with rounded Tread-Section

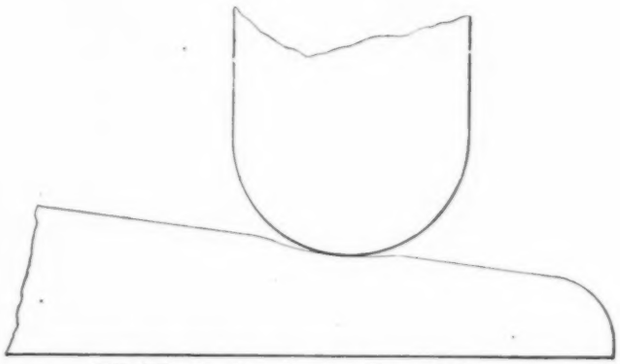


FIG. 4 Showing Channel worn in Flange of I-Beam

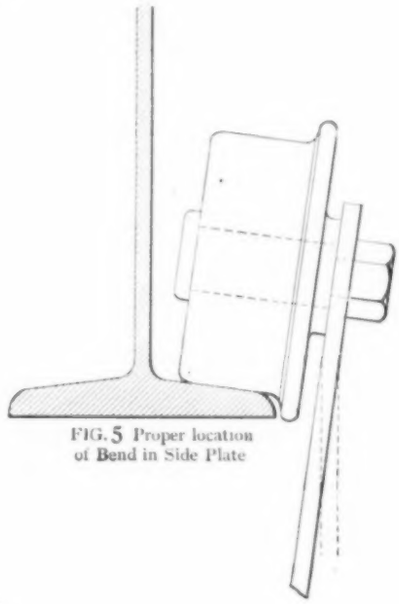


FIG. 5 Proper location of Bend in Side Plate

tween the wheel and the path enormously. When new the stresses on the plate would be exactly the same as for the conical type; but after a little wear it would make for itself a ridge in the I-beam (provided the wheel tread is hardened by chilling) as in Fig. 4, and thus cause no thrusting action on the plate whatsoever.

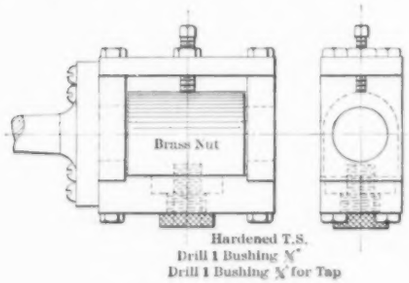
At page 773, Vol. 29, Part 2, another trolley is illustrated which shows what appear to be cast-iron side cheeks. As I said before, these trolleys are very often subject to such rough usage and jerks that it is very risky to use this brittle material. If steel is used they cannot be bolted together easily unless the plates are bent and brought parallel.

In some trolleys, I have seen this bend put in the center, between the trolley wheel stud and the bottom bolt; but this is surely bad design as the load would tend to straighten the plate. It should be made with the bend as near the stud nut as possible, as shown dotted in Fig. 5.

SKRIBISTO.

A Jig for Lathe Cross-feed Nuts

The drawing shows a very useful jig that was designed by me for boring, tapping, and finishing the carriage-feed nuts for a Niles 80-inch wheel lathe. No doubt considerable time was spent in rigging up the lathe for the operation in the old manner. The accuracy was doubtful, and considerable trouble was experienced when the nuts were applied to the lathe carriage, as the inaccuracy of the operation was plainly shown.



JIG FOR FINISHING NUTS

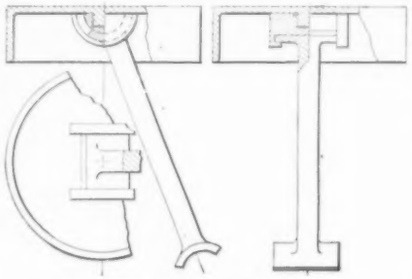
Our trouble has entirely disappeared as a result of the use of this jig, as is clearly shown in the drawing. The shank is tapered to fit the lathe spindle, and the housing is made up of rolled steel, so that no time is spent in machining the steel. The collar on the nut is faced in the lathe chuck to fit the 2x7/16-inch counterbore in the bottom of the jig. The set-screw is tightened on the nut and the drilling operation performed, using a 5/8 drill and tapping it 3 inches, United States standard. A 3-inch bolt is inserted to hold the nut central for the boring operation. The nut is lined with the sides of the jig for alinement with the center, and the boring and tapping are done.

The time consumed in making these nuts is considerably less than that needed for the old method.

HARRY F. KILLEAN.

What is Wrong with Piston Pins?

The readers of E. I. Bartlett's article on "Piston Pins," on page 454, Vol. 29, Part 2, may find half pins, as per drawing herewith, of use where shortness of the engine is a desideratum. They are not patentable. I used them on a two-cylinder Brotherhood.



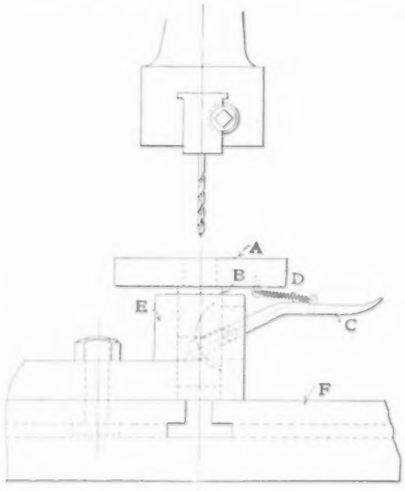
WRIST PIN FOR A SHORT ENGINE

LAU. HARGRAVE.

An Attachment for Sensitive Drilling

Having 7000 small holes to drill and nothing to do it with but a heavy 30-inch drill press, I looked long and wonderingly at the job. The size of the drill was 0.042 inch diameter. The thickness of the plate was 3/16 inch. Work was scarce and we had need of all we could get.

After breaking a couple of drills and coming to the full realization that our equipment was inadequate for such work, I asked permission to make a sensitive attachment for the drill press. I was granted permission, provided I made the attachment in a half day. It seemed rather risky, but when one is "hard up" for a solution he will try almost anything.



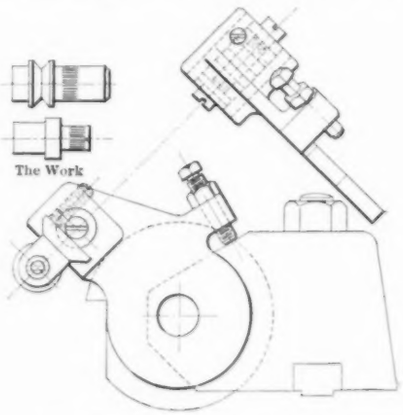
AN ATTACHMENT FOR SENSITIVE DRILLING

The platen *A* was made from an old cast-iron disk 4 inches diameter and 7/8 inch thick; the spindle *B* is a piece of 1-inch diameter cold-rolled steel turned down to 3/4 inch and driven into *A* after drilling and filing the slot for the handle *C*; the body *E* was made from an old bell crank which had been broken, but the hub was just the right length and after boring the hole and reaming it to fit the spindle *B* and facing the straight side, it was all that could be desired. The forging of the handle, filing and drilling it to suit took but a short time. When all was ready it was bolted to the drill press platen *F*. The results were good but after adding spring *D* all went well, and the work was finished satisfactorily.

JOSEPH N. GERMAIN.

A Nurl Holder for the Automatic

The sketch shows a nurl holder, designed for the Brown & Sharpe automatic screw machine, and so constructed as to furnish a means whereby the relative distance between cutting-off tool and nurl can be varied as occasion requires, without necessitating the use of cutting-off tools of different thicknesses. It is chiefly used for raising a nurl on a piece so that a gear or pulley can be forced on and held without soldering or pinning.



NURL HOLDER FOR THE AUTOMATIC

The nurl itself is held in an adjustable slide which can be moved back and forth in a direction parallel to the spindle of the machine, and securely clamped in position. The body of the holder is clamped to the tool post with the same screw that clamps the cutting-off tool, yet it can be adjusted with the adjusting screw without disturbing the cutting-off tool. The holder is designed to be used on the rear tool post, but it can be used on the front post when the nurl on the work does not have to be close to the chuck.

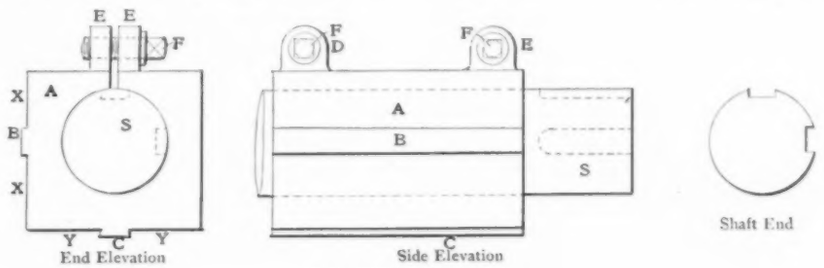
The operation of the tool can be readily seen from the sketch, which also shows the work operated upon. We have equipped all of our Brown & Sharpe automatics with this style of nurl holder, and it has proved very satisfactory in its operation.

AUTOMATIC.

Fixture for Milling Two Keyways at Right Angles in a Shaft

Having a large quanitity of brake drum shafts for automobiles, which required two keyways 4 inches long by 7/16 inch wide, cut at the end, 90 degrees apart as shown in the illustration, we designed the fixture shown which is very satisfactory, and exceedingly simple and accurate.

The sketch explains itself: *A* is a gray-iron block milled on the two surfaces marked *x* and *y*, exactly at right angles with each other—as upon this the accuracy of the work depends; *B* and *C* are two tongues to fit the vertical milling-machine table T-slots; *D* and *E* are two lugs, and *F* are two ½-inch set screws for gripping the shaft to be operated upon.



THE MILLING FIXTURE

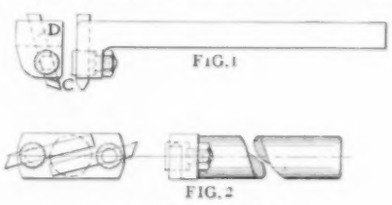
The shaft is clamped in position, and the fixture held down by a single clamp, on top in the center, and a keyway is milled with a slot drill. The block is then turned on the other side of the square, and fastened down, and the remaining keyway milled.

ROVER.

England.

Rigid Boring Tools

Fig. 1 in the accompanying sketch shows a handy boring tool-holder, made of tool steel, to be used on various kinds of lathe work. A slot *D*, 5/16 inch wide by 5/16 inch deep, is milled in the tool-holder at a suitable angle to give the tool the required top rake. A hole is bored and counterbored through this slot to suit the steel stud *c*, through which is a 5/16-inch square hole that clamps the tool in the tool-holder, as shown.



RIGID BORING TOOLS

Fig. 2 is a double boring tool-holder for turret or screw-machine work, and, as will be seen, is made on the same order as the lathe tool, Fig. 1.

GEO. V. HUBER.

The Art of Cutting Metals

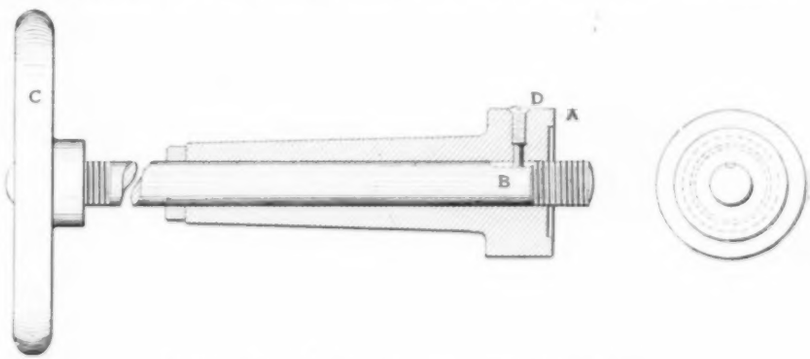
I would like to say a few words in reply to Entropy's article at page 116 on the above subject.

It is not the art of cutting metals of which I would speak, as that is quite a broad subject, but of the men, whom Mr. Taylor's system takes so little into consideration. The vast majority of workmen will not read the technical works on their trade, nor will they have anything to do with anyone or anything that would tend to teach them the theory of their trade. They are examples, generally, of a too practical education, and they are prone to live in the present, caring nothing absolutely of the past or future. The development of the trade is to nearly all shopmen an unknown quantity, and their future intentions and prospects the same. One reason for this, as I've discovered, through constant association, is the fact that there are no works written upon the subjects that would interest the shopman, and upon things which he could be induced to inform himself about. For example: where may you obtain a good reliable book on engine-lathe *work*? I can hear your answer: No, that is not it. The work you have in mind treats of the early history of lathe; of hand lathes; of automatic lathes; of monitor lathes; of engine lathes and, finally, near the last, the patient shopman finds a few chapters on this *work*. Writers should bear in mind the fact, when writing books for the shopman, that he is a man capable of thought in but one line, or in the particuar branch of the machinist trade whereby he lives. Then, and then only, can we hope to realize the intelligent, educated machinist; he will not, because he cannot, start to climb up from the middle of the ladder; but, like all things in nature, the machinist, both the practical and literary one, must have a beginning, and that beginning must be, literally, a beginning, and not a figurative one. As to correspondence schools, their success is doubtless due to their recognition of this rule. I am acquainted with two ex-planer hands that are now, respectively, assistant superintendent and foreman toolmaker in one of the largest plants in New Jersey. But they began by first learning to draw a straight line, then a right angle, and their progress was by degrees, not leaps and bounds. Nor was a history of the life of Archimedes at all necessary to their success. I am well aware that I have written very positively; but I am forced to these conclusions, after a shop experience covering about nine years, and I have continually searched, in vain, for proof that could lead to other and more cheerful convictions.

"MACHINIST."

Chuck for Circular Tools

The accompanying sketch shows a chuck used in the turning of circular screw-machine tools which are used mostly on automatic machines. The taper sleeve *A* fits in the lathe spindle. The tool to be turned is screwed on the end of *B*, which passes through the spindle of the lathe and is clamped to the face of *A* by the hand-wheel *C*. The screw *D* acts as a key to *B*, preventing its turning when tightening or releasing the hand wheel. As shown it is very nearly half-size for a Hendey-Norton lathe.



CHUCK FOR HOLDING CIRCULAR TOOLS IN TURNING

GEO. V. HUBER.

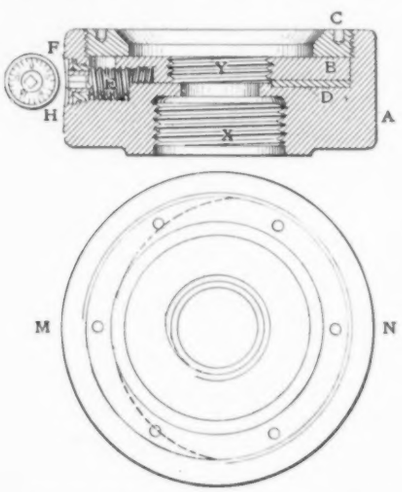
A Boring Head

Most operators on universal milling machines and boring mills know how unsatisfactory are the methods usually employed for setting out the cutters in enlarging holes. The common method amounts to drilling out the starting hole, unless it is cored; inserting the boring tool

and starting a shallow cut; withdrawing the tool and calipering the hole; tapping out the cutter an indeterminate amount, if the hole is too small, and so cutting and trying until at length it is "just right"—a very tedious and unsatisfactory method. After various forms of boring-tool adjustments had been tried, none of which proved satisfactory, the attachment shown in the drawing was designed.

It will be noticed that it is designed to fit the nose of the machine spindle at *X*, and consists of a cast-iron body or shell *A*, and a sliding plate *B*, which is turned to fit the inside of the body *A*, and then set over and, with the same diameter, reduced to a sort of an ellipse, as shown by the dotted line in the front view. This plate has a half nut cut to engage the screw *E* by which it is moved. The plate *B* is gibbed down by the ring nut *C*. This adjustment is not designed to be changed after it is once made right. The amount of wear is insignificant. In fact, it was found desirable to pin the ring to prevent its being moved. To insure the plate *B* moving in a straight line, a key *D* is provided. A nut *F* retains the screw *E* in its pocket, and a graduated dial *H*, riveted on the end of the screen, allows readings to be taken to determine accurately the amount of set over, a zero mark being made on the body. A suitable wrench is provided to operate the screw.

In the drawing it appears that the sliding plate *B* is internally threaded at *Y*. To this was fitted the rear end of the body of a "Little Giant" drill chuck. Ordinarily this chuck held the shanks of all the various boring bars, but for extra large and deep holes a special bar was provided, one end threaded to fit *Y* and a shoulder against the face of plate *B*. In operation, the plate *B* was set concentric, as shown in the drawing. After running through as



A BORING HEAD FOR A MILLING MACHINE

large a drill as was practical, the drill was exchanged for a boring bar. Sometimes this was a tool taken from a lathe-tool board, just an ordinary boring tool made out of round tool steel, with the end or cutting lip forged up. By setting the lip of the tool radial with the line *M N*, it is obvious that by adjusting the amount of set over by the reading on the dial *H*, the exact depth of cut required could be made. It is also possible to use the drill for the same purpose as the boring tool, though it is not so stiff.

This attachment, if well made and fitted, will carry heavy cuts at a good distance from the head without undue spring. It will be seen that the outside is made smooth, and without projections, which is very agreeable to the operator. It is also dirt proof. It was designed by Herman Casler, and has been in use for six years or more.

H. D. Pomeroy.

Another Style of Broach for Internal Gears

It seems to me that L. E. S., who describes a gear-broaching job at page 118, went to a great deal of expense in making his broach, and that even then it was not all he wished, because it tended to creep, a weakness quite common to broaches, by the way.

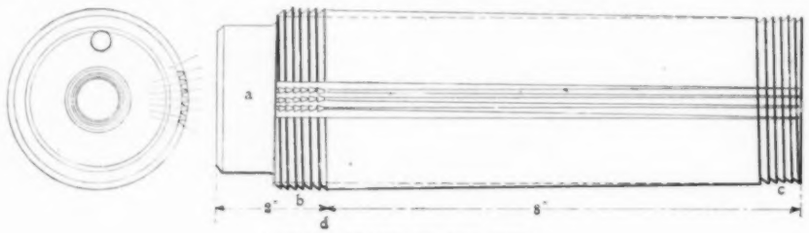
If I had that job to do, I should make the broach solid, save a great deal of labor and have a broach which could not creep if it wanted to. I should thus be able to make the broaching operation the last, or the last but one, as there might be a tendency to tear a little at the bottom corner, although the gears would be true in spite of it.

Selecting the Steel

A piece of tool steel large enough to turn to the outside diameter of the gear, in this case 3.116 inches, and, without any calculation beyond a desire for good proportion, 10 inches long, will serve for the broach. It should be centered and one end turned, as indicated at *a* in the sketch; then it should be swung in a steady rest and the center drilled and tapped with a one-inch pipe tap, and the edge of the hole trued up for a center. A piece of one-inch pipe screwed in the end will serve to handle the broach while heating and tempering.

How it is Made

Next it should be turned at *b* for about an inch, to the outside diameter of the gear, and the end *c* to the diameter at the root of the teeth, which will correspond with the hole in the gear blank. Then the tailstock should be set over (on such slight taper I prefer this to the taper bar) to turn a straight taper from *c* to *d*. Then, while the lathe is adjusted for the taper, a ratchet thread of eight to the inch, as shown, should be cut the entire length of the broach. After setting the tailstock back to place, the threads at *b* are cut



A GEAR BROACH IN ONE PIECE

straight, which gives eight teeth to hold the finish size. Now it is ready for the teeth, which are cut parallel, the cutter just touching at *c*, and going full depth at *b*. The formula $\frac{2.157}{P}$ for the full depth of the tooth shows this to be 0.1078; and, as there are eight inches of taper and eight threads or teeth to the inch, each tooth will have a little less than 0.0017 inch to cut, which is just a nice chip. When the teeth have all been cut, if the cutter is kept sharp so that there are no burs, the broach is ready to harden, without hand work of any kind being put on it.

Spring in Hardening

A little springing in this kind of a broach does not make any special difference, as the final sizing is done at the end *b*, too short to spring; and, as the bottoms of the teeth correspond with the hole in the gear blank, it serves as a guide and prevents creeping.

This is not intended as a criticism of the method used by L. E. S., which seems to be all right mechanically, but to show another means of reaching the same results in a more direct way.

Theodore.

A File Holder

The illustrations show a jig for holding a file to draw-file templets, gages, etc. It is a neat little tool, does its work nicely

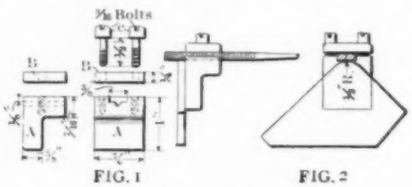


FIG. 1 FIG. 2

A FILE HOLDER

and keeps the edges square and true. Fig. 1 shows the jig in detail. Fig. 2 shows it in use. It is very easy to take the lumps off with this tool, and keep the edges square all the time.

W. T.

Molding the Adams-Farwell Cylinders

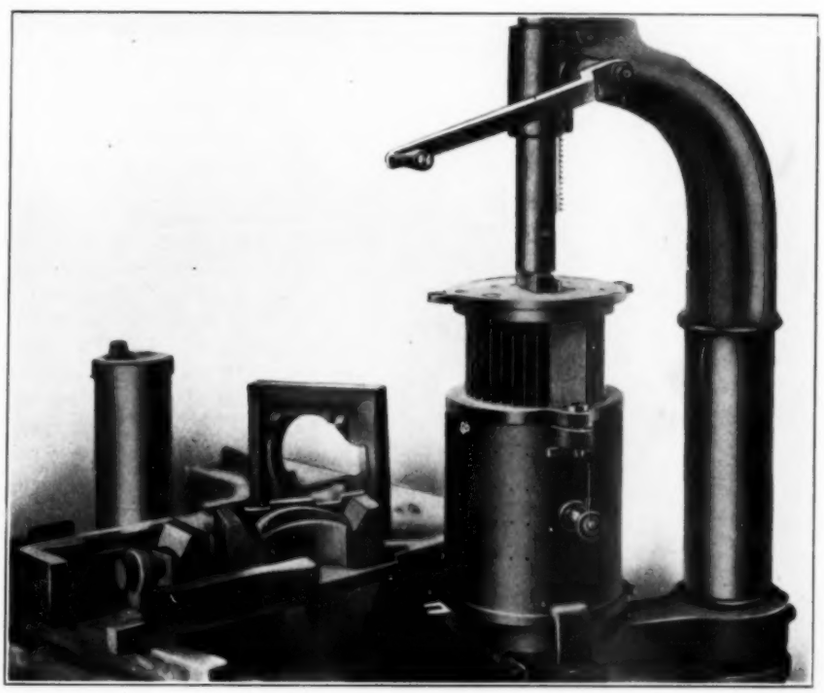
We notice, at page 5, you make mention of methods of casting the Adams-Farwell air-cooled motor cylinders. We have molded these cylinders in several ways and until we used the method we now employ we had much trouble in getting uniform castings. This method is described as follows:

The pattern is cast iron with flanges running parallel with the cylinder. These flanges do not have appreciable draft in any direction. The pattern is coated with solution of bayberry wax and plumbago. It is then placed in a small round iron flask for the purpose of making a dry-sand mold. The sand is composed of three parts sharp sand, one part molding sand, and one-half part flour.

After the sand is rammed it is placed in the oven, with the pattern still in the sand, and baked for two hours. It is then taken from the oven and placed on the machine, as shown by the accompanying photograph, which draws this metal pattern out of the sand through a stripping plate that is securely held on top of the mold. This forms the main part of the mold.

In making the complete mold this dry-sand part, together with the round iron flask, is placed in a large wooden flask, and sand is rammed around it to hold it in place. The port core is then placed in position inside of this main dry-sand mold, followed by the placing of the barrel core. The balance of the mold is completed by placing two dry-sand mold sections around the top of the barrel core, which extend up about 3 inches beyond the mold cavity. The joints of the dry-sand sections are then sealed up with clay and green sand is filled in around the flask to hold all firmly together.

On one side of the two top sections are two openings, one for the gate to connect with the sprue, the other to connect with the riser. Just before ramming the sand entirely around these sections, wooden blocks or sprues of proper shape are placed in position, and after the sand is rammed sufficiently hard these are taken out, leaving the sprue hole for pouring, and the riser hole. A weight is placed on the top of the barrel core to prevent its floating when pouring. In the center of the barrel core is a hole about one inch in diameter extending nearly to the bottom. The mold is vented through this hole, allowing free escape of the gases.



MOLDING THE ADAMS-FARWELL CYLINDERS

C. L. Butler.

The Adams Company, Dubuque, Iowa.

Machining Gears

We had a large number of gears, 5 inches pitch diameter, 3/8 inch face, with a long hub on one side, as shown at *A*. Owing to the large number to be done I made the jig shown at Fig. 1. I do not as a rule care to use threaded bushings on jigs for accurate work, but in this case the work came out within a limit of 0.002.

A plate *B* was made and the yoke *C* secured to it. The boss in the center of the yoke *C* was threaded to receive the case-hardened bushing *D*. The lower end of *D* is internally tapered so as to center the hub of the gear *A*. The upper end of *D* is provided with a handle *E* so that no wrenches are necessary. A pin *F* in the plate *B* bears against one of the arms of *A* and prevents it turning.

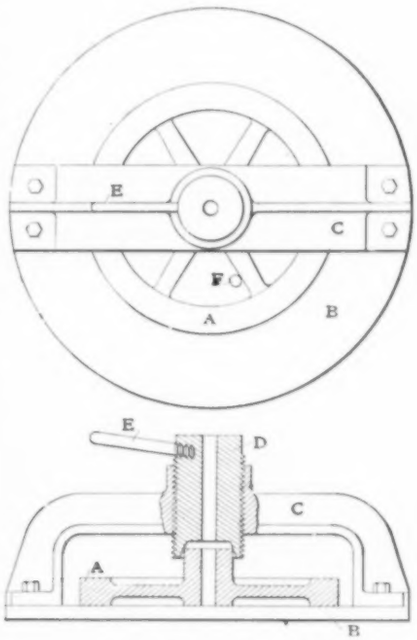


FIG. 1. THE DRILL JIG

The gears were cast from a metal pattern, which allowed 1/32 inch, where finish was necessary, and as the molding had been carefully done this allowed plenty for finish.

The gears were all drilled first with the jig. The bushing was then taken out and a reamer 0.002 undersize, with a long pilot, was put in the drill-press chuck and put through each wheel. The wheels were then taken to a lathe, where a full-size reamer with a long pilot was mounted in

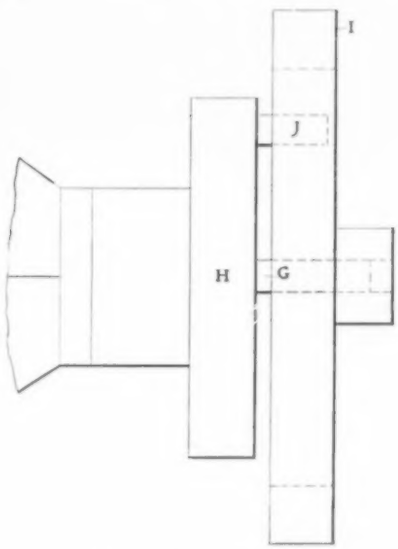


FIG. 2. THE FLOATING MANDREL

the chuck. The operator held the wheels with his hands and reamed them a good deal more quickly than it takes to tell about it.

A floating mandrel *G* was then mounted in the lathe, and the gears put on one at a time. A face plate *H*, smaller in diameter than the rim *I*, with a pin *J* in it, drove the gears. A straddle tool was used to face both sides of the rim at once. After the sides of the rims of all the wheels were finished, the tool was set to diameter and they were all sized. As the castings had all been well rattled and pickled the tool stood up quite a while without re setting. The ends of the hubs were also finished on a floating mandrel.

The whole job was finished in record time. The pinions were 1 3/12 inches pitch diameter, 3/8 inch face, and were finished in much the same way. With them, however, there was no preliminary drilling, an old 5/8-inch reamer being sharpened to cut on the end, and run through. This was easy as the pattern was made to leave its own core, which left only 1/64 inch all around for finish This cannot be done with the average run of castings, but where I got these they were not considered anything out of the usual.

WATT.

Molding Hard Rubber

Molding of hard rubber presents so many problems that in this article I will give only the general principles controlling it. If we could make a mold of metal, plaster, or sand, melt the rubber and pour, the same as with metal, the process would be much simplified. As rubber cannot be melted without destroying its strength, or once dissolved cannot be brought back to a solid state in a mold, it has to be molded when it is of the consistency of bread dough.

Pure hard rubber is the rubber gum of commerce, washed of all impurities, and mixed with sufficient sulphur to vulcanize when heated. Before vulcanizing, this compound is of a yellowish gray color; and after vulcanizing is black, requiring no coloring matter.

The rod is the most simple to make. The compound is placed in a machine and squirted. As it comes from the machine it is cut to length and placed in a box containing powdered soapstone. The rods must not touch each other or the box. The box must be tight enough to keep the steam away from the rubber while vulcanizing. The gray appearance of the unfrazed rod is caused by the soapstone in which it is vulcanized. Tubing is made the same as the rod, with the exception that it is squirted over a mandrel, which is removed after vulcanizing.

FIG. 1. SECTION OF HARD-RUBBER COMB

Sheet hard rubber is made by passing the compound between calender rolls set to the thickness desired, and then covering with tin foil by carefully rolling it on by hand so that the foil is in contact with the compound at every point. The finish of the sheet hard rubber is given to it by this foil, no handling being necessary after vulcanizing except to peel off the foil and square up the edges.

Molding thin articles, that have both sides exposed, is done by taking the sheet while it has the tin foil on it ready to vulcanize, and pressing it between dies. Fig. 1 shows a cross section of a comb, with the foil on, ready to vulcanize. After vulcanizing, the tin foil is stripped off, leaving the surfaces with the same finish as commercial sheet hard rubber.

All other hard-rubber goods are made in molds generally of tin cast in iron molds. As the molds have to be absolutely free from pin holes and of a high finish, it can be readily understood that the art of soft-metal casting reaches its highest state of perfection in a hard-rubber factory. Master molds are made by forming a piece of steel exactly the same size as the desired article. This should be as highly polished as possible, then fastened to a bed plate, a frame placed around it, and a flat cover placed over the frame. When clamped together these complete the mold ready to pour. The frame should be thick enough to give the tin strength at the thinnest point. The cover should have a pour hole and at least one riser.

In pouring, the mold must be at the same temperature as the metal that is being poured and placed on an incline, so that the metal will always rise from the pouring hole, and, after pouring, it must be cooled at such points as will chill the metal on the polished surfaces first. When done rightly, the tin casting will come out with as high a finish as the master mold and without shrinkage.

For molding a one-sided piece, I show the master mold for a revolver grip, Fig. 2, the frame, Fig. 3, and the cover, Fig. 4. A tin casting from this is the rubber mold, and is used by filling the depressions with rubber compound, placing a sheet of tin foil over the compound, and applying pressure, which completes the molding ready for vulcanizing. After vulcanizing, the piece comes from the mold with as high a finish and the same size as the master mold, all the shrinkage coming on the foil side on account of its being flexible.

For molding a piece on which all outside surfaces are exposed, I show the master mold of a syringe nozzle, Fig. 5. The parts *E* are formed, of steel, exactly as the nozzle is required, split apart, and fastened to a bed plate in such a relation to the lug *D* and the depression *C* that two tin castings from the same master mold, when placed face to face, will register; that is, the edges of the depressions formed by the parts *E* will meet at every point. Use a frame, as shown at Fig. 3, and cover like Fig. 4 to complete the master mold.

The rubber is molded by forming the compound into a tube, closing both ends, not forgetting to put a few drops of water

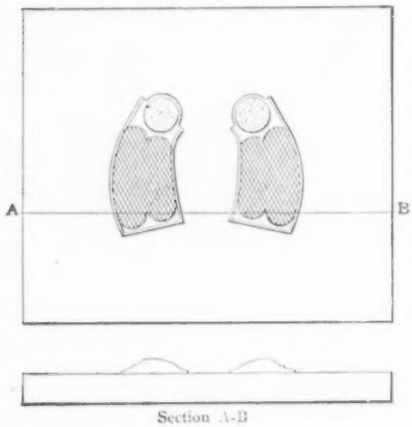


FIG. 2

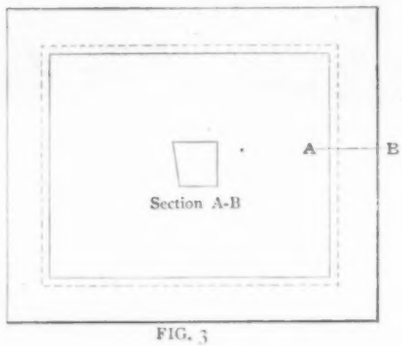


FIG. 3

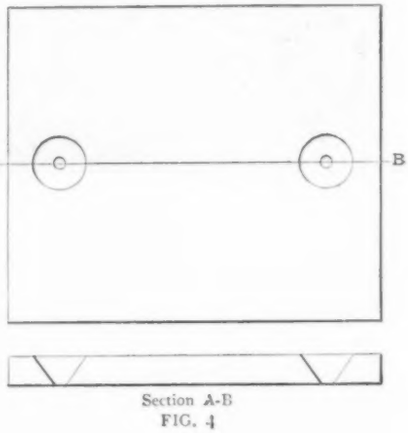
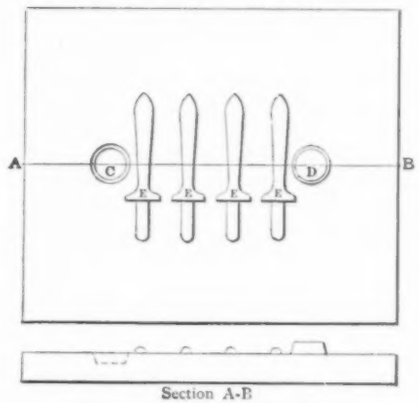


FIG. 4

COMPONENT PARTS OF A RUBBER MOLD

inside. Fill the tin half-mold with these tubes; place the other half-mold over them, clamp them together, and vulcanize. In vulcanizing, the water inside the tubes turns to steam and forces the rubber against the walls of the mold, thereby tak-



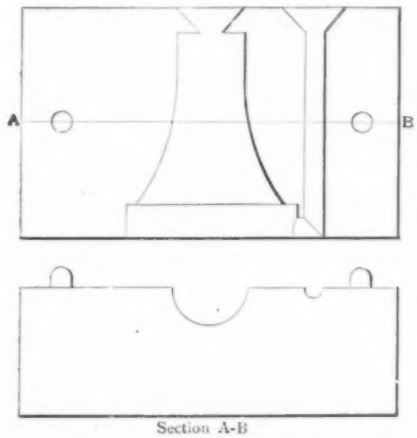
Section A-B

FIG. 5. SYRINGE-NOZZLE MOLD

ing care of the shrinkage so that the finished nozzle is the same size and finish as the master mold.

A piece that is exposed both inside and outside is generally done on a mandrel. I show one-half of a mold for a mandrel for a telephone mouth-piece, Fig. 6. The two halves of the mold must be made exactly alike so as to register at every point. In pouring, the halves are clamped together, placed on the pouring plate, Fig. 7, and poured with a constant stream. The water for cooling is applied under the pouring plate, and when properly done the mandrel will be without imperfections and the same size as the mold.

The rubber is molded by wrapping the mandrel with the rubber compound and placing it in a box of powdered soapstone. After vulcanizing, the mandrel is removed, leaving the inside of the rubber finished.



Section A-B

FIG. 6. TELEPHONE-MOUTHPIECE MOLD

The outside is then turned to size and finished.

This article would not be complete without giving a description of the most difficult rubber molding, that is, the molding of plates for false teeth. First, the cast of the mouth is taken in plaster. This is used as a pattern for one side of the rubber mold which is made of plaster in an iron flask. The pattern for the other side of the rubber mold is made by taking a wax cast of the original plaster cast, and placing the teeth on the wax in the proper place. After molding, the wax is removed from the mold, usually by melting, leaving the teeth imbedded in the plaster. This leaves the two parts of the mold an exact fit. The second side of the mold is then cut away to give room for the proper thickness of rubber. The rubber compound is then carefully packed in the mold, pressed together and clamped, ready for vulcanizing. After vulcanizing, the rubber is given the desired finish.

Vulcanizing is done, by steam heat, in boilers, varying from four inches diameter and eight inches long, to six feet diameter and as long as desired. The steam can be generated in the vulcanizer or in a separate boiler. The pressure and the length of time required to vulcanize depend on the amount of sulphur in the compound and the bulk, and varies from 90 pounds and one hour to 55 pounds and ten hours.

While the pure compound is a mixture of the washed gum of commerce and sulphur, it is seldom used without adulterants, for with pure compound the shrinkage is excessive, it is hard to mold, and the cost is higher than the ordinary consumer cares to pay. A compound suitable for a great many purposes can be made with 10 per cent. of pure compound. Articles of compact shape, similar to the wheels for furniture casters, are made from powdered hard rubber without the addition of any new compound, being molded in steel molds with high heat and pressure.

All metals except copper, and alloys except those containing a high percentage of copper may be molded in rubber and vulcanized without trouble. Metals and alloys giving trouble can be used after coating with hot tin.

All base metals except tin will leave a metallic surface on rubber, when the rubber is vulcanized in contact with them. This is the reason that electricians find so much trouble in the surface of sheet hard rubber, and the cause is the adulteration of the tinfoil in which the rubber is vulcanized.

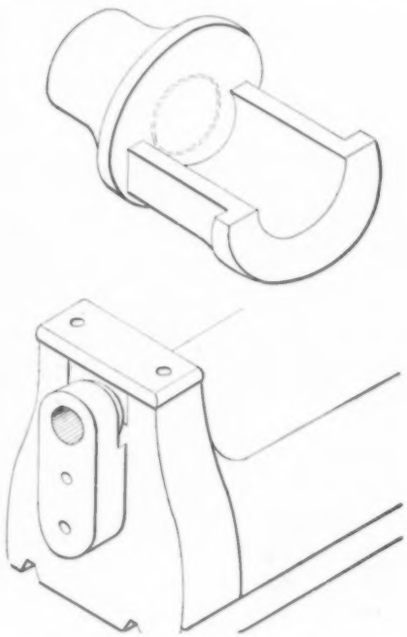
J. BERTRAM.

Repairing a Turret Lathe

The thrust bearing of a big turret lathe was made as shown in the top sketch, with square corners *x x* to invite a break. A husky turret man, with more muscle than judgment, jammed work into the chuck with the turret till one day the back end of this bearing dropped off.

The work was piled up waiting for the machine, and there was no time to lose in waiting for a new box, or a casting, or any fancy spider-legged forging to take its place. So we took a piece of 2½x3½-inch machine steel which was in the blacksmith shop, and had him cut off a piece 10 inches long; gripped this in a four-jawed independent chuck in an engine lathe so as to bore the hole and thread for the thrust screw, and then faced the whole surface to fit squarely against the back of the lathe head, as shown in the lower part of the figure.

The face was recessed around the screw to fit the end of the box at that end, and the boring tool hooked through far enough to bevel the outer end of the hole. The bolt holes drilled, and others drilled to match in the back end of the head, completed the job in a very short time as compared with waiting for a new piece,



A THRUST BEARING AND HOW IT WAS REPAIRED

or any other way out that I know of.

That thrust block has been in place 15 years, has withstood the thumps and assaults of numerous untrained and unrestrained muscles, and has never even winked in all that time. It isn't artistic and it might not be best for all conditions, but it did the business in this case better than anything I know of.

FRANK C. HUDSON.

Our railroad friends will be glad to learn that a new era of locomotive performance has arrived. All that is now necessary is to thoroughly test the engine with the indicator and that ever thereafter the only attention it needs is to be fed with coal and water, with an occasional coat of paint, to keep it going forever. At least that is what a daily paper says of some tests on the Chicago & Alton Railway.

Air-cooled Gas Engine Construction—II

Methods of the Knox Automobile Company in Drilling and Tapping for the Application of Cooling Spines to Automobile Cylinders

BY HUGH DOLNAR

As is well known to all investigators of heat transmission, any joining in the substance of the transmitting agent is a great hindrance to the transfer of heat. No matter how closely the abutting surfaces are forced together, the heat is impeded at the juncture, not a little, but very greatly. For this reason all air-cooled cylinder applied radiating surface extensions are wrong, and only integral ribs, spines, horns and projections are correct. In spite of this, the first pronounced success in car-motor cylinder air cooling was made with small steel spines, ¼ to 5/16 inch diameter, and about 1¾ to 1⅞ inches long, threaded the whole length and screwed into holes drilled and tapped about ⅛ inch deep in the Knox cylinders, according to a patent isued to Harry Knox, a young draftsman and machine designer, of Springfield, Mass., and exploited by the Knox Automobile Company, of the same town, with pronounced success, in the Knox car-motor. This was long shown in the opposed pair of cylinders form only, and is here illustrated in that form.

After the Knox cars were established successes Mr. Knox sold his interests in the air-cooled motor, and the Knox car to the company, for, it is said, $150,000, and is now building cars in Springfield, driven by two-cycle water-cooled motors.

The Completed Cylinder

The Knox cooling scheme involved the increasing of the cylinder radiating surface by screwing wrought-metal spines into the cylinder surface, so that the completed cylinder should show as in Fig. 1, about 1800 of the threaded steel spines being screwed into the surface of the largest cylinder and about 1000 spines in the smallest cylinder.

The shape of the Knox cylinder casting is shown in Figs. 1, 4, 5, 6 and 7. The cylinder head is integral with the cylinder walls, the short, branching, intake and exhaust pipes, and the cylinder flange. The radiating spines are applied to the whole exterior of the head and cylinder body, including rounded and dome-shaped portions of the head in some of the models; so that the spine holes must be drilled at many different angles to make each spine stand at right angles to the cylinder surface at the point of application.

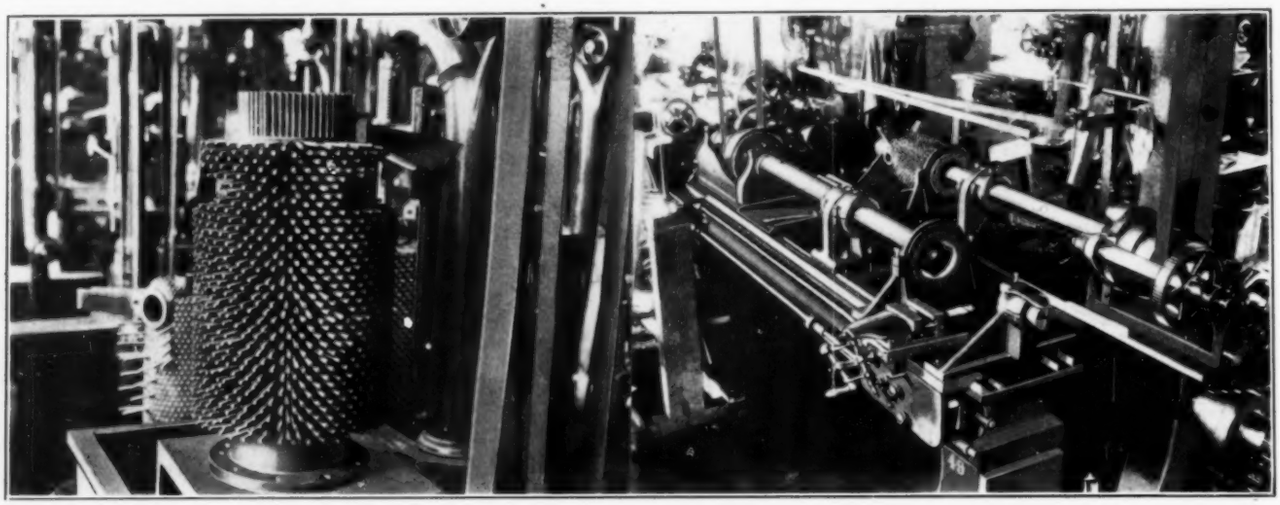


FIG. 1. COMPLETED KNOX AIR-COOLED CYLINDER

FIG. 2. CYLINDER-BORING LATHES

Machining the Cylinders

The first operation on the cleaned and pickled cylinder castings is to finish the flange and neck, which are used for fixing the location of the cylinders in all subsequent operations, by turning the outer flange face, the flange edge and inside surface and part of the cylinder up to the first boss, as shown in Fig. 5, at *N*. The second operation is drilling the flange for the holding bolts.

The cylinders are bored, as shown in Fig. 2, on ordinary engine lathes with long boring bars carrying single boring tools, as shown in Fig. 3; these boring bars are screwed on the lathe-spindle nose and are carried in large capped bearings on pedestals fitted to the lathe shears, as shown in Fig. 2, so as to leave the boring bar overhung and clear for a length at the tailstock end, sufficient to pass through the cylinder-supporting fixture bolted to the lathe saddle and to reach the bottom of the cylinder cut.

As there is no opening through the Knox cylinder heads, the bar cannot have a tail stock support, and the cylinder bore is therefore always taper, about 0.002 small at the head end. This whole job of cylinder boring as here shown is several years old and was a make-shift at first, with the intention of prompt betterment, but had not been changed in the early part of 1906, when I last visited the Knox shops. A special cylinder-boring machine, however, was then in place, but not yet in regular use, as it had not yet shown so well as the lathes and overhung boring bars.

The cylinder boring shown may be called fair New England shop practice, though it is far from ideal, as the unsupported cutter-carrying end of the bar is sure to feel and follow differences in the cylinder-wall hardness and texture of metal. The men who were boring the Knox cylinder said, nevertheless, that the bores produced were straight and round, and had the specified taper.

The cylinder fixture consists of front and rear angle pieces fixed to the lathe-saddle ends, with a sliding, screw-pinched tail spindle in the rear upright, while the front upright is capped and bored to fit the cylinder neck *N*, Fig. 5. The first boring operation finishes the cylinder to rough-bore size, probably not more than 0.008 or 0.010 under finished diameter.

The cylinders have also several milling and boring operations, only one of which

is shown, in Fig. 4, where a heavy knee milling machine is finishing the branch-pipe ends with an inserted-tooth end mill. None of the valve-seat finishing operations are shown, save the hand finishing and grinding of the valve seat in Fig. 5. I regret to say that I trusted my memory for the hand tool here shown in use, and have now forgotten what it is like.

Drilling the Spine Holes

All the machining except finish-boring is done on the cylinders before the spine application begins by drilling the holes as shown in Fig. 6. The cylinder is supported in various positions on wooden fixtures fastened to the round tables of small vertical-spindle drillers. Some of these fixtures have indexing fixtures, with sliding carriages, all being of wood, with metal joints for the tilting tables, metal latches and notches or pins in holes in metal plates for sliding fixture locating, and metal index plates.

The whole job is very complicated, and plenty of work was done in locating the spine holes to give an equal radiating effect to all parts of the cylinder by the radiating spines. The wooden fixtures are very curious structures, are cheap, convenient and quickly handled; but they were regarded with much disfavor in the shop because they were makeshifts, and, it was said, would soon be replaced by carefully designed, multi-spindle special drilling machines, and for this reason no attempt was made to show the various wooden drilling-fixture constructions, soon to be obsolete. Two years later the whole cylinder-spine plant had been moved to another part of the shop, and the same wooden fixtures were in use, seemingly as good as ever, the special drillers not having emerged from the drawing room.

Sleeve-gage Drilling

The drilling is done with twist drills of more than usual length for diameter, surrounded by a sleeve-gage, a piece of steel tube larger inside than the drill diameter, pierced with holes to let the chips out, fixed with screws to the drill body, and hardened at its lower end which impinges the cylinder surface to determine the depth of the hole, all as shown in Fig. 6. The fixture is indexing and also slides to a latched position endwise for each circle of holes, and the index plate and index pin shift on their spindle hub to make the circumferential location of the hole change in each subsequent circle of holes, so as to place the pins in spiral rows.

Tapping

The holes are tapped ⅛ inch deep, to the bottom of the hole with a peculiar reversing tapping chuck shown in Fig. 7, the chuck which holds the tap dropping off its driving-clutch pin when the point of the tap bottoms in the hole; and the upward lift of the drill spindle by the hand of the driller reversing the chuck movement and backing the tap out of the hole. The tapping proceeds rapidly, with almost no failures, though I have a dim memory of a statement that where the hole thread did strip, a larger tap and radiating pin were used. The lack of a single pin would

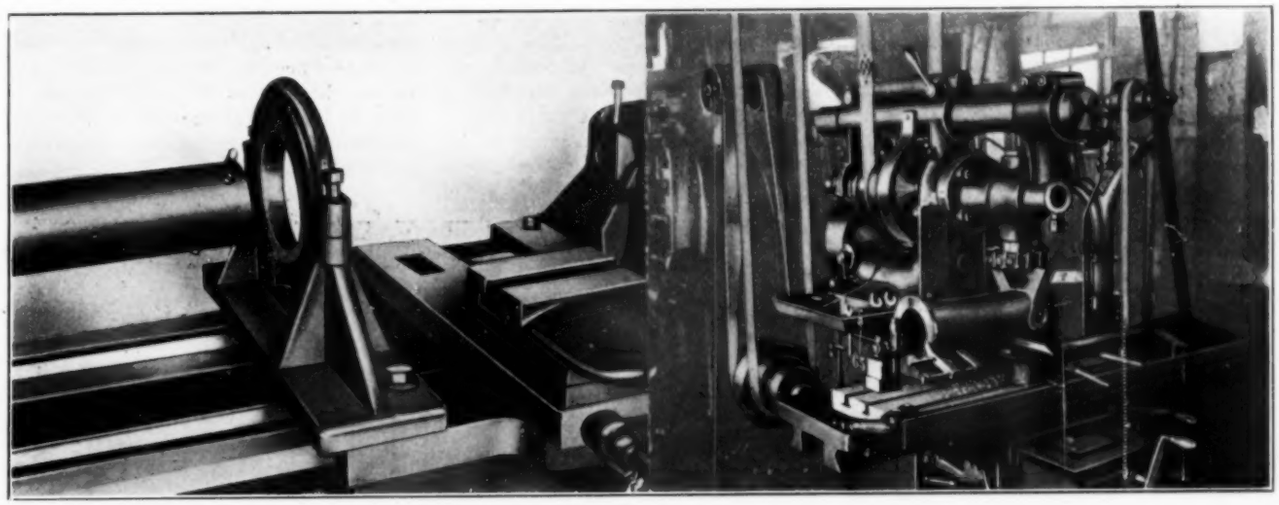


FIG. 3. SINGLE-TOOL BORING BAR

FIG. 4. FACING THE EXHAUST- AND INTAKE-PASSAGE ENDS

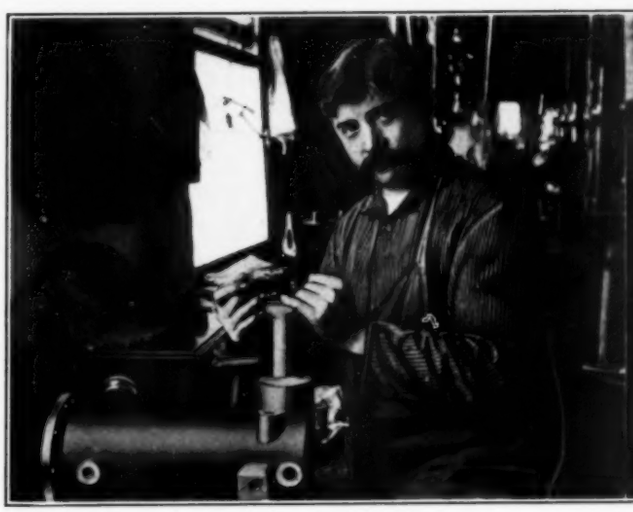


FIG. 5. HAND-REAMING VALVE SEATS

FIG. 6. DRILLING CYLINDER SPINE-HOLES

cause an intolerable blemish in the appearance of the completed cylinder.

The pins themselves were not made by the Knox company at the time these pictures were taken. The pin stock rods were threaded full length, and then cut into pin lengths on a turret machine with a rod feed, the parting tool shaped to make one flat end and one 120-degree point on each pin.

Inserting the Spines

Fig. 8 shows the pin-inserting bench, the cylinders standing on a flange, retained by a wooden plug fitting the cylinder bore, fixed to a rectangular wooden base, as shown at *F*. My recollection is that the T-wrench socket used was threaded to fit the pin thread and took the pin until the head bottomed, and that the T-wrench was backed off the out end of the pin thread after the point was in to its

tor, with the cylinder full of cold air at the beginning of the compression stroke. The ultimate cause for this great variation in air-cooled motor compression is not known. The immediate reason for low compression is the prevention of pre-ignition.

From this account it will be seen that the Knox spined cylinders are not low-cost by any means, nor are the motors high-power for their bore and stroke. The motors are cooled with fans at the cylinder heads, the cylinders not being incased.

This method of increasing cylinder radiating surface is very peculiar indeed, requiring considerable special tool making and much ingenuity in tool and fixture designing, and the method is not likely to be followed by others. The Knox factory is in excellent condition, as might be expected from its home in close proximity

or ten tip pieces, arranged end to end. The suggestion, however, presented several difficulties, not the least of which was the extreme awkwardness of holding, also the number of operations, and consequently tools, fixtures, etc., required. In addition, under attendant conditions these tools would necessarily have been expensive to construct.

Making Four at Once

After due consideration I decided that by taking advantage of the radius at *A*, Fig. 1, I could arrange four of the finished pieces in such a manner as to form sections of a circle, of which these were arcs. This arrangement left just sufficient margin between them for cutting through, as shown by the dotted lines in Fig. 2. Moreover, the resulting piece being square outside and circular inside, lent itself very readily to holding

FIG. 7. TAPPING SPINE HOLES

FIG. 8. CYLINDER SPINE-APPLYING FLOOR

threaded seat in the cylinder. The T-wrench socket may, however, have been fitted with a loose jaw or jaws, so supported as to hold the pin to turn it into its seat and release the pin after seating when the wrench was turned in reverse direction. The recollection is that 2½ hours was the time required to seat 1800 spines in the largest cylinder, which would be 12 pins per minute or one every five seconds of total elapsed time, and is probably about the actual time.

The final operation on the cylinder is finish boring after all the spines are in place. Cylinder grinding was just being installed at the time of my last visit to the Knox factory, and not enough was known of the action of the special grinding machine to warrant description.

I do not know the Knox motor compression, but it is probably low. Air-cooled motor compression varies greatly, being as little as 27 pounds, in case of one well-known motor, and as high as 55 pounds in other cases, and I have seen 60 pounds gage pressure shown on an air-cooled mo-

to the Springfield armory, the birthplace of American repetition small-machine production.

Machining Rifle-sight Tips

By B. Norton

A completed sight tip as used on the Lee-Metford and other pattern small arms for the insertion of the back V sight is shown in Fig. 1. There is usually an increased demand for this attachment about the time of the Bisley Summer competitions, bad and doubtful sighting often being corrected by the removing and replacing of back-sight tips with new ones which are trued to the competitor's instructions upon the spot.

A sample and quantity having been submitted for quotation, this was duly brought into the machine shop. It was suggested from the office that strips (the material being malleable iron) should be cast sufficiently long to cut up into eight

while being machined, and brought the cost of the cutter and fixture work down to about 40 per cent. of what would have been required to work the strip castings. There was also every possibility of obtaining a good finish, which seemed very remote under the conditions first suggested.

The Tools Used

Commencing with the cored hole a roughing, and afterward a finishing reamer give a nice bore of a uniform size, this being absolutely necessary as a foundation for subsequent operations. A facing cutter with pilot to fit the hole next trimmed up the two ends, being stopped to correct gage for length.

The four remaining sides were squared up in the milling machine with three straddle cutters. These were arranged upon milling as shown in Fig. 3. The bored and faced casting was slipped on to the arbor in the inclined index head, locked up with a nut and collar, this collar having a small featherway which en-

gages the peg at *B* to prevent movement when the nut is locked up, Fig. 3. The slide, running parallel with the spindle axis, was stopped between two suitable points and the work was fed into the spacing between the cutters. A good plan to obtain a definite gage between cutters so arranged is to make up screwed collars, as shown in Fig. 4, with three or four holes around for pin adjustment; the troubles with a solid collar usually experienced after regrinding or reversing the cutting faces will disappear altogether. Locating the work for this squaring operation is by swiveling the flat spring *C* which is brought into position when pieces are slipped on the arbor and afterward moved away for cutting. A quarter of a turn of the index plate gives alternate positions for feeding between cutters.

The dovetailing came next. This, it will be noticed, is across or opposite the hole. A vertical milling machine being available, it was decided upon as being most convenient to use for this operation. Fig. 5 shows the simple, but effective means of holding; *D* is an arbor having three slits and expanded by the cone pin. The cutter was made of such a size that one cut only was needed. *E* is the flat spring to which pieces automatically accommodate themselves when fixed as in the previous operation.

Separating the Pieces

The cutting apart of the four tips followed next. This was accomplished with work again placed on the arbor in the head, Fig. 3. Under similar conditions to the squaring operation, but with two saws equal to the width of the spaces indicated by dotted lines at *E* and *F*, Fig. 1, holding, indexing and stopping were identical. There was at the outset a doubt as to whether the pieces would remain in position upon the arbor after being severed by saws, which of course happens when one has made the first two cuts; there was, however, in practice no difficulty experienced in this respect, providing that all faces were kept clean and freed from cuttings after each removal.

The last operation was the radius in which the V is cut when sighting, shown at *G*, Fig. 1. The dovetail is made use of for holding in this case, Fig. 6 being the machine fixture. The steel plate *H*, dovetailed at the end to receive the tip *I*, is cut through into the hole *J* as shown, this being made large so that the expansion screw need not be screwed up too tightly for fear of distorting the tips. A plain end-milling cutter run at a fairly high speed and kept sharp was used in this last instance. It may be interesting to add that a plentiful supply of suds was used throughout, and the finish was all that could be desired.

In 1905 399,302 short tons of lead were produced in the United States, being about 5000 tons less than in 1904.

The Millionaire Apprentice

By F. A. Stanley

Said old Solomon Brown, as he settled down
For his noon-hour smoke in the shade:
"You can say that I'm dumb, but I've noticed, by gum,
Some curious shifts in the trade.
Why, the shops to be found in the country around,
Like everything else of the sort,
Are all being run by some gentleman's son
Who hasn't learned what he ought.

"The men on the spot seem a different lot,
'T least the fellows I run across;
There's too many cubs and too many dubs
And too many species of boss;
And too many chaps who are looking for snaps,
With their heads full of figures and stuff,
Are playing like boys with mechanical toys
And throwing all kinds of a bluff.

"Now, there was that slim McSwilligan Jim,
The son of the millionaire;
I worked with old Mac some forty years back,
When things were more on the square.
But Mac stowed away about all of his pay,
While I spent mine as it came;
And now as you know he's the head of the show,
And I—I'm out of the game.

"Young Jim, by the way, as I started to say,
Thought he'd follow the old gent's line;
He'd tackle the shop, soon be at the top,
And there in his element shine.
When he entered the race at his father's big place,
What a splurge all the headlines made:
A Wealthy McSwilligan Works in the Mill Again ! ! !
Learning His Father's Trade ! ! !

"But Jimmy was smart, and he didn't start
At the pace that the Old Man kept;
He didn't contrive to awaken at five
While the rest of the family slept;
And he didn't talk of a three-mile walk
Nor think of the night trip back.
Times had changed in town since Solomon Brown
Was a 'prentice along with Mac.

"What time do you s'pose young Jimmy arose?
'Twas eight or eight-thirty perhaps;
Why, the rest of the shirks had got to the works
Long before he had finished his naps.
And no walking for Jim, no trolleys for him,
No bucket of grub for his lunch,
'There's no object,' said he, 'of a pull, as I see,
If I've got to follow the bunch.'

"In his runabout trim to work he would skim
With Hawkins, his man, at his side;
They'd pass in a blur with a honk and a whirr—
Great Scott! how those fellows would ride!
Poor Hawkins held hard but got cruelly jarred
From the top of his head to his heels,
While Jim stayed aboard by the grace of the Lord
As he handled the levers and wheels.

"Now, the yard was supposed to be rigidly closed
When the whistle had blown, of course,
So James didn't wait till they opened the gate
But carried the same by force.
Now, he didn't worry because in his hurry
He'd busted a section of fence,
For repairs that were done for McSwilligan's son
Were considered a shop expense.

"When this indolent pair got to work, I declare
They appeared like a couple of larks:
Jim's elegant suit and his valet to boot
Drew many sarcastic remarks
And this charming young dude swore his work must include
Every recent mechanical kink,
But he never would touch a shop order—not much—
Unless it was scented and pink.

"And all through the day things went on in this way:
'Say, Hawkins, examine this mill;'
Or, 'Hawkins, me man, replenish this can;'
Or, 'Hawkins, just polish this drill.'
He was kept on the rush with the waste and the brush
And trotting about the shop,
While his boss would insist he'd not dirty a fist
In working his way to the top.

"Say, Jim was delighted (?) by being invited
To drill some 'B-42' caps—
'Just get me the fixture, and, Hawkins, a mixture
Of bolts and a couple of straps.'
Now according to rules when a man went for tools
All tokens but checks were debarred,
But Hawkins could get the whole outfit, you bet,
By flashing McSwilligan's card.

"While his valet collected the tools as directed
McSwilligan smoked in his chair—
A special upholstered, padded and bolstered,
Comfortable sort of affair.
When Hawkins, the jay, brought the tools on a tray
And piled up the castings near by,
Mr. James would arise, blow the smoke from his eyes,
And tackle his job with a sigh.

"Thus Jimmy the fop made his way through the shop
In a leisurely sort of a style;
Whether running the miller, the lathe, or the driller,
Or playing with hammer or file,
He spent little muscle, and never would hustle,
But always was raising a fuss,
Till every machinist, the best and the meanest,
Just hated the sight of the cuss.

"Oh, yes, I will grant, he's now boss of the plant
A Captain of Industry too;
And you'll hear the remark, from those in the dark,
That Jimmy McSwilligan grew
From a three-dollar boy in his father's employ
Till he stood on the summit of fame,
That a couple of years 'midst the belts and the gears
Taught him all that there was to the game."

Senator Kittredge has reported to the Senate a joint resolution passed by the legislative assembly of South Dakota petitioning Congress to remove all restrictions which will tend to prevent the domestic manufacture of denatured alcohol to be used exclusively for mechanical purposes, fuel, or lights. A similar petition was presented by Senator Gamble. Senator Hansborough presented a resolution along the same lines emanating from the legislature of North Dakota; and also urging that legislation be passed which will permit of the conversion of waste farm products into denatured alcohol.

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The Fly-wheel Hazard

There are several reasons for the fact that fly-wheels are more dangerous things than boilers; chief of which, perhaps, is the fact that they are not, in general looked upon as dangerous things, and hence less care is given to their design than to the design of boilers. Fly-wheel joints have not been made the subject of careful study to the extent that boiler joints have been, many fly-wheel joints being scarcely designed at all, in any true sense of the word. Of course, that may also be said of many boiler joints; but, on the other hand, there are many well worked out tables of boiler joints which in average cases may be safely used by those who are incapable or unwilling to design each joint by an application of first principles, while such tables do not exist for fly-wheel joints, if indeed their calculation is a possibility.

Added to these considerations is the further one that, until comparatively recently, there was a general misunderstanding regarding the strains in fly-wheel rims. Not very long ago it was universal, as it is still very common, to regard the forces acting in fly-wheel rims as the same as those in boilers, resulting in simple tensile strains upon the rim and the link or bolt of the joint. The fact that, when the joint is placed midway between the arms, as is customary, the parts of the rim lying between the joint and the nearest arms act as cantilevers and produce a bending as well as a tensile strain upon the joining pieces, was, so far as we know, first recognized in actual design by E. D. Leavitt, who, a good many years ago designed a fly-wheel for the Calumet & Hecla Mining Company in which tension rods were carried from the joints to the hub of the wheel. The conception of this action is not yet a general one; but the experiments of Professor Benjamin have shown beyond any doubt that joints of this class fail by reason of this action, and that the leading strain upon the joining pieces of a joint placed midway between the arms is this bending strain, and not the tensile strain, as is too frequently considered. It is this action which gives the very low efficiency of 25 per cent. which goes with the common lug and bolt joint.

To these considerations must be added the fact that strains upon fly-wheel joints may be far more readily and far more rapidly increased beyond the normal working load than in the case of boilers. In the nature of the case, the increase of pressure in a boiler is gradual, with plenty of opportunity for discovery before it reaches the danger point, whereas the strain upon a fly-wheel increases with great abruptness and with very little opportunity for preventive measures. The strain upon a boiler shell increases directly with the pressure, while the strain on a fly-wheel rim increases with the square of the speed. It is scarcely to be conceived that the working load on a boiler shell should be multiplied by four without being discovered, whereas that is the result upon a wheel rim of doubling its speed; and when from any cause the governor of an engine loses control and the engine begins to race, it does not take long for the speed to be doubled.

A given factor of safety as applied to a boiler means an equal factor of security, while that is far from being the case with a fly-wheel. The factor of security for a fly-wheel should be figured from the standpoint of speed rather than from that of strain, and a factor of safety of four as regards strain is only a factor of security of two as regards speed. This is a consideration which everybody understands, but, on the other hand, very few give it due consideration.

Growth of the Machine Tool Industry

Bulletin 67, just published by the Bureau of the Census, presents statistics relating to the manufacture of machine tools, there classified as metal-working machinery, in the United States in 1905.

The total value of metal-working machinery manufactured in 1905 was $32,408,766. Despite the fact that this industry had only partially recovered from the general industrial depression in 1903, the census shows an increase of $7,670,862, or 31 per cent., in the value of metal-working machinery manufactured in 1905 as compared with 1900. An increase varying from 8.4 per cent. for New Jersey to 87.3 per cent. for New York is shown for all the leading States except Pennsylvania, for which a decrease of 9.6 per cent. was reported. The greatest absolute increase in value of products is shown for Massachusetts.

Almost nine-tenths of the total value of products of the metal-working machinery industry was reported for eight States lying east of the Mississippi and north of the Ohio river and Mason and Dixon's line. Ohio is by far the leading State in this industry, reporting over 25 per cent. of the total value of products, or more than New York, New Jersey, and Pennsylvania combined. Cincinnati and Cleveland, which ranked first and second, respectively, among the cities of the country, reported nearly three-fourths of the total quantity of such machinery produced in this State, and about one-fifth of the total for the United States. Massachusetts ranked second among the States, and Connecticut and New York were, respectively, third and fourth.

The depression which ensued in 1903, especially in the iron and steel industry, affected the foreign trade in metal-working machinery to a very marked extent. The exports decreased from $7,193,390 in

1900 to $2,826,111 in 1903, while the imports increased slightly. At the time of the census, however, the industry was beginning to recover from the depression and a large increase in exports was noted.

Lathes were the principal class of metal-working machinery manufactured in both 1900 and 1905, their value forming 18.3 per cent. of the total at the later census. A considerable decrease is noted both in the quantity and value of lathes manufactured, most of this decrease being for engine lathes.

Although the number of milling machines manufactured in 1905 was slightly less than in 1900, the value was considerably greater. The reverse is true of boring and drilling machines, which were of almost equal importance with milling machines in the value of the product.

New York reported more than one-half of the total value of stamping, flanging, and forming machines manufactured. The total value of this class of machines increased almost 100 per cent. between the two censuses. The most marked increase shown for any class of metal-working machinery was for pneumatic hand machines, the manufacture of which was of little importance in 1900, but was of such extent in 1905 as to be entitled to fifth rank among the products of this industry. The number of such machines manufactured increased 12,546, or almost twofold, and the value, $1,588,782, or over elevenfold.

A slight decrease is shown in the production of planers, boring and turning mills, and slotters and shapers; while there was an increase in the production of punching and shearing machines, grinding and polishing machinery, bolt, nut, and pipe-threading machines, and steam, power, and drop hammers.

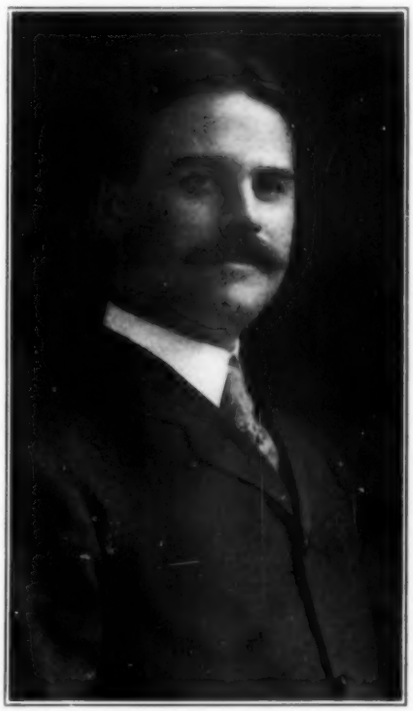
A large increase is shown for "all other metal-working machinery," which is composed largely of small tools and duplicate parts for metal-working machines. The value of this class of products formed 28.1 per cent. of the total value for the industry in 1905, as compared with 11 per cent. in 1900, but as suggested in the bulletin a considerable part of the increase is probably due to the greater comprehensiveness of this class of products in 1905.

Among the curious duties imposed by the Australian Government is one on catalogs, which pay a duty of 3 pence per pound and, in consequence, tons of such catalogs are destroyed every year by the customs authorities after the business men to whom they are directed have refused to pay the duty. It would appear to be useless to send catalogs to Australia, unless arrangemnts have previously been made insuring the payment of the duty, or unless the sender sends the money himself by international postal money order to the comptroller of customs at an appropriate port.

Harry C. Hoefinghoff

Harry C. Hoefinghoff, president of the Bickford Drill and Tool Company, Cincinnati, Ohio, died March 2 at the Bethesda hospital in that city, where he had undergone an operation for appendicitis three days before.

Mr. Hoefinghoff was the elder son of Charles Hoefinghoff, of Cincinnati, where he was born September 26, 1871. Upon completing his common-school education in 1886, he entered the foundry of the Hoefinghoff & Lane Company, of Cincinnati, of which firm his father was president up to the time of his death in 1898. The interests in the Hoefinghoff & Lane Company were then sold and he succeeded his father to the presidency of the Bickford Drill and Tool Company.



HARRY C. HOEFINGHOFF

Harry Hoefinghoff was one of the most prominent young men engaged in the manufacture of machine tools in the country. He was an important factor in the affairs of the National Metal Trades Association, the National Association of Manufacturers and the National Machine Tool Builders' Association. He was also a member of the Manufacturers' Club and the Business Men's Club, of Cincinnati, and one of the promoters of the Cincinnati Factory Colony Company, on whose property the Bickford factory, as well as a number of other large manufacturing concerns in that city are to be erected.

Mr. Hoefinghoff was considered one of the most promising young business men of Cincinnati. He was quick in perception, accurate in judgment and persistent in purpose. His affability of manner may be said to have been one of his most pronounced characteristics, winning for him popularity among an unusually wide circle of business associates and fellow townsmen. He is survived by his wife and three children.

Charles Harding Loring*

By W. M. McFarland

The death of Admiral Charles Harding Loring (chief engineer U. S. Navy, retired) on February 5, 1907, removes a man who had been a prominent figure in engineering circles and in our society for many years. He was a member of the society almost from its organization and had filled its highest offices, being vice-president in 1885-87 and president for the term 1891-92. However great a man's professional ability, his free election to such high offices is a strong testimonial to his worth as a man, and is, indeed, the highest tribute of the personal regard in which he is held by his fellow-members.

He was born in Boston, December 26, 1828, and received his education in the public schools of that city. As his educational period was before the day of technical schools, he followed the usual course of preparation for mechanical engineering and served a regular apprenticeship in the machine shop. At its close, in 1851, he entered the navy as a third assistant engineer, attaining, by competitive examination, the highest place in the class of fourteen.

His entrance was just too late to give him an opportunity for participation in the Mexican War, and by the time the Civil War broke out he had passed through all the junior grades and had become a chief engineer. A portion of his service in junior grades was as assistant to the engineer-in-chief of the navy, Samuel Archbold, having charge of the experimental work and tests of engineering devices coming before that office. It is interesting to note that while engaged in this duty he made a test of the first injector which came to this country.

During the Civil War he was in active service the whole time, and during the first 18 months was fleet engineer of the North Atlantic station, being attached to the fine old steamer "Minnesota." He was on board this ship during the attacks of the "Merrimac" on the Northern fleet in Hampton Roads on the 8th and 9th of March, 1862, when the "Cumberland" was sunk and the "Congress" burned, and when the "Minnesota" also was attacked.

During the Civil War a number of excellent engines had been accumulated for hulls which were in process of construction; but with the close of the war all

*From advance proofs prepared for the *Proceedings of the American Society of Mechanical Engineers.*

work was stopped, and after a time a board was appointed to recommend the best disposition of these engines, which were stored in the various navy yards. It was about this time that the compound engine was coming into general use, and the same board was directed to make a study of the compound engine, with a view to its introduction in naval vessels. Of this board Admiral Loring was senior member, and associated with him was the late chief engineer, Charles H. Baker.

After a very exhaustive study of the subject, they recommended the introduction of compound engines and the abandonment of the simple form, and the conversion of a number of the engines which were on hand into compound engines. Four sets of these simple engines were so converted and were fitted to the "Vandalia," "Marion," "Quinnebaug," and "Swatara." The tests of these engines were very satisfactory and showed a cost economy for short runs of not much over two pounds of coal per horse-power hour.

In 1881 he was a member of what is known as the "first naval advisory board," appointed by Secretary Hunt to formulate a ship-building program for the navy which he might submit to Congress. The personnel of this advisory board was distinguished in all its branches, and the work they did made possible our splendid fleet of today, as they definitely decided, against strong professional opposition, to abandon wooden hulls for those of iron and steel, and acted for general progress in every respect.

On the retirement of Engineer-in-Chief Shock, the qualifications of Admiral Loring were so well recognized that the appointment as his successor came to him entirely unsought. This was in 1884, during the administration of President Arthur. The change of policy which followed, the purchase of plans abroad and other events convinced Loring that he did not have Secretary Whitney's confidence and that for the sake of his corps, he had better give up his office as engineer-in-chief. Accordingly, in 1887, he tendered his resignation.

After leaving the bureau of steam engineering he was made senior member of the experimental board of naval officers at the New York navy yard, which board, under his direction, conducted many exceedingly valuable experiments. Among the most important were the competitive tests in 1889 of water-tube boilers to determine the type that should be used on the coast vessel "Monterey;" and it may be well here to call attention to the fact that this was the first case on record where a boiler had ever been run continuously for 24 hours when burning more than 50 pounds of coal per hour per square foot of grate.

Another very important series of experiments conducted by Admiral Loring were those on the boilers of the torpedo-boat "Cushing," to determine the economy of evaporation with different air pressures and rates of combustion. These experiments have proven of the greatest interest, and form a very valuable collection of engineering data. A number of clever devices had to be schemed out to carry on these tests, and the whole success was a great credit to Admiral Loring and the board.

Having reached the age limit in December, 1890, he was placed on the retired list; but having always been a man of very vigorous physique, he did not give up active employment, and was for a time consulting engineer to the United States and Brazil Mail Steamship Company. During the late war with Spain he was recalled to active duty and assigned inspector of engineering work in New York City.

Admiral Loring was a man of great personal attractiveness, and to most of his friends the social side of his character was the more important. They admired

ADMIRAL CHARLES HARDING LORING

the able engineer, but they loved the man. Although a man of great dignity, this only repressed undue familiarity, and he was a delightful companion. His keen sense of humor and remarkable skill as a *raconteur* made him a decided addition to any company. It was remarked by a brother officer, himself remarkable for his abilities as an entertainer, that Loring was the best "diner out" in the navy. He wrote well, and was a good speaker, doing these with the dignity and elegance which were a part of his nature.

He was president of the Engineers' Club for two years, thus receiving the highest social honor which engineers can confer. His incumbency of the presidency of our own society has already been mentioned. He was a vice-president of the Society of Naval Architects and Marine Engineers from its organization until his death, and while his health permitted was very active in its council and general meetings. The Army and Navy Club, of New York, owed much to his active interest, as he had filled most of the offices and was for a number of years its secretary. He was also a member of the Loyal Legion and of the Grand Army of the Republic.

Obituary

James W. Weaver, who from 1869 to 1898 was master mechanic of the Lehigh Valley Railroad shops, at Sayre, Penn., died at that place February 13. Mr. Weaver was a veteran of the Civil War, and for the past nine years had been postmaster of Sayre.

Personal

R. E. Hallman, recently with the Barrett Manufacturing Company as a mechanical draftsman, has taken a position with the Consolidated Engineering Company on steam specialties and vacuum heating system.

T. S. Peck, who has about 15 years' experience as foreman and superintendent of various machine shops, has taken a position as machine-shop foreman at the Studebaker Brothers Manufacturing Company, South Bend, Indiana.

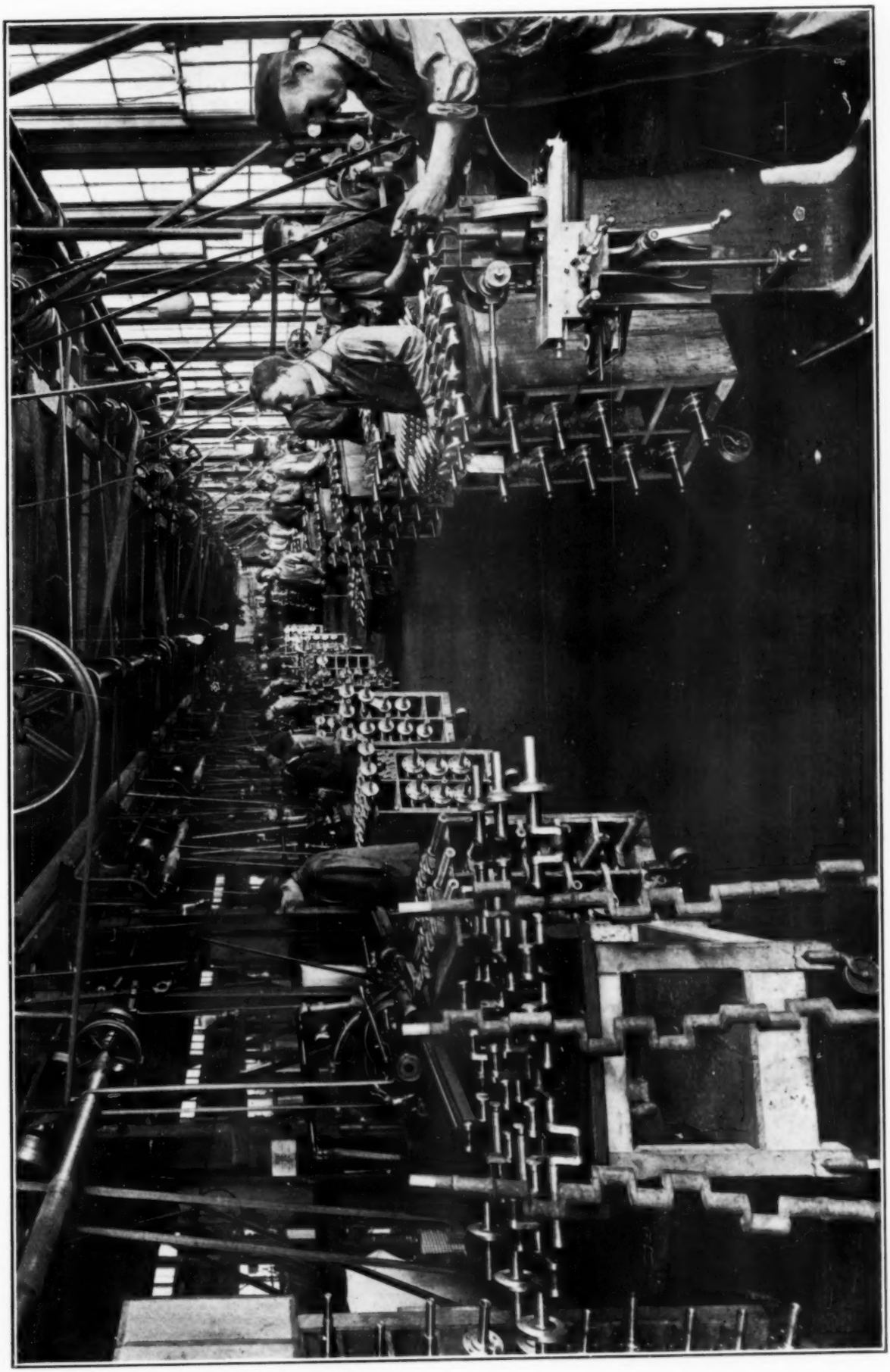
H. D. MacDonald, chief draftsman tool designing department and assistant master mechanic of the J. J. Case Threshing Machine Company, Racine, Wis., has accepted a position with the International Harvester Company, on automobile construction. He assumes his new duties May 1, 1907.

Dr. W. H. Tolman, director of the American Institute of Postal Service, 287 Fourth avenue, this city, has been appointed Commissioner General of the American Section of the International Book and Paper Exposition, to be held in Paris, from July to November of the present year. All inquiries regarding the exposition should be sent to him.

In spite of the growth of the export trade in automobiles, the gross value of machines exported is less than of those imported, the figures standing $4,409,000 and $5,000,000, respectively.

So far steam turbines of the Parsons type have been manufactured to give a total of 870,000 horse-power. Of this 200,000 horse-power came from American builders, and 350,000 horse-power from the original Parsons works in England.—*Machinery.*

The steel, fireproof passenger car is slowly but surely extending its field of operations. Forty of them have recently been built for the subway and elevated line in Philadelphia. They are superior to those of the New York subway in having side doors in the middle of the body, as well as vestibule doors at the ends. The doors are opened and closed by compressed air. The cars are 49 ft. 7¼ in. long over the platforms and will seat 52 persons.



THE AUTOMOBILE INDUSTRY—ONE THOUSAND CRANKSHAFTS IN GRINDING ROOM OF NORTON GRINDING COMPANY, WORCESTER, MASS.

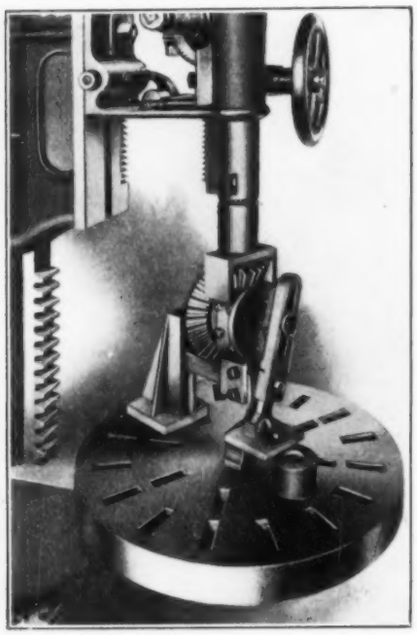
New Tools and Machine Shop Appliances

Showing the Progressive Development of Modern Shop Equipment and the Progress of Design in This Department of Work

THE LATEST INFORMATION

Slotting Attachment for the Drill Press

This attachment is designed for cutting square and rectangular openings, and may be applied to the drill press by slipping the taper shank into the spindle, and bolting to the table the vertical slotted bracket which prevents the body of the device from turning when the machine is started. The cutting tool is pivoted on a shank projecting below the body, and is given an oscillating motion by the slotted arm



SLOTTING ATTACHMENT FOR DRILL PRESS

and crank disk, the latter being driven, as indicated, by bevel gearing. The teeth on the round head of the cutter operate on the work as the tool rocks back and forth about its center; the cutter is of course oscillated rapidly under a light feed. By setting the work in a fixture which may be fed across the drill-press table, a slot of any desired length can be cut. The attachment is made by J. M. Smith, 568 St. Marks avenue, Brooklyn, N. Y.

A File-sharpening Machine

Fig. 1 shows a sectional view of a machine for re-sharpening dull files by a blast of steam and air carrying an abrasive. With this machine files can be re-sharpened for about 10 per cent. of the original cost. The number of times a file can be re-sharpened depends upon the work for which it is intended and upon the cut. Fig. 2 shows the jet which throws the abrasive against the file. Fig. 3 shows the tooth of a new file, and Fig. 4 a file which has the points of the teeth dulled by use. The dotted lines in Fig. 4 show

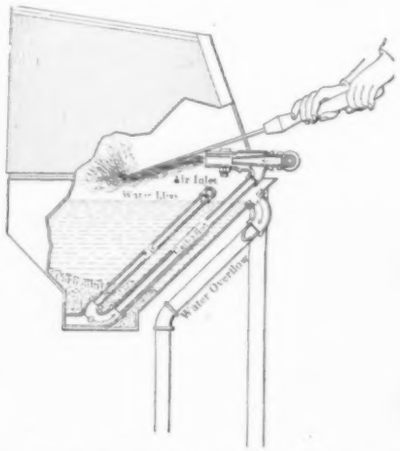


FIG. 1. SECTION THROUGH FILE SHARPENER

where the abrasive cuts away the steel and leaves a sharp cutting edge.

These machines are made by the American File Sharpener Company, 296 Broadway, New York.

An Extension-gap Lathe

The illustration shows an extension-gap lathe with motor drive. The lathe swings 24 inches over the bed and 46 inches in the gap.

The carriage is extended for turning the full swing of the lathe and is supported at its outer end by an angle bracket with an adjustable gib on the lower bed.

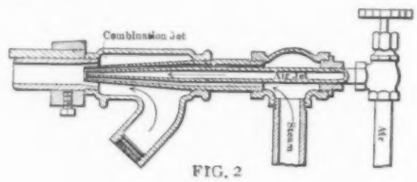


FIG. 2

FIG. 3

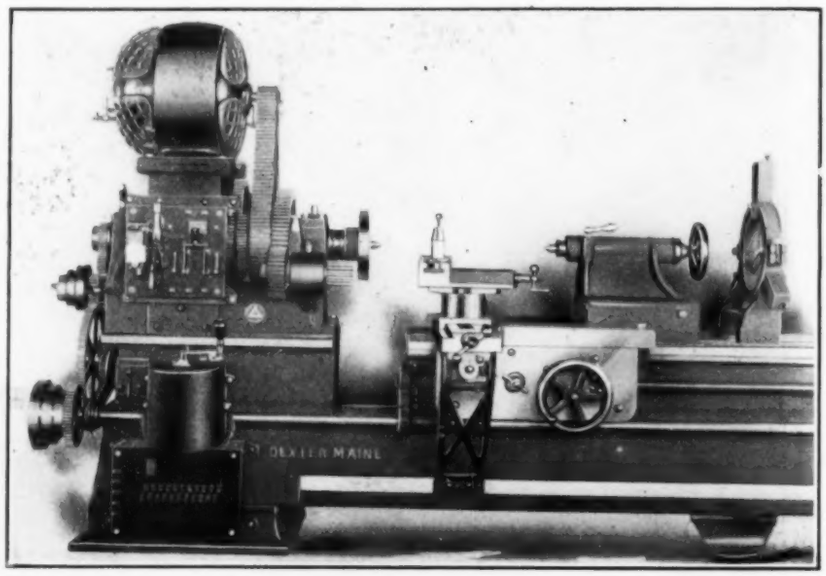
FIG. 4

NOZZLE AND ENLARGED FILE TEETH

Extras such as taper attachment, follower rest, turrets for carriage or V's, friction head, triple geared direct to face plate, are furnished if desired.

The front bearing of spindle is 4 inches diameter by 6⅜ inches long. The spindle has a 2 1/16-inch hole through it; weight of lathe with 8-foot bed, 6600 pounds.

This lathe is made by Fay & Scott, Dexter, Maine.



AN EXTENSION-GAP LATHE

New Publications

A Study in Graphite, by W. F. M. Goss. 46 6x9-inch pages, with 25 illustrations. The Joseph Dixon Crucible Company, Jersey City. Price, 25c.

This pamphlet is a record of various tests made by Professor Goss to determine the value of graphite as a lubricant. It includes a description of the testing machine used, and gives the results of tests of graphite used in various ways—dry, mixed with oil and with water, and combined mechanically with the brass of a journal box. The growing appreciation of the value of graphite, not only in emergencies but as a lubricant for continuous service, gives a good deal of value to this re-publication of Professor Goss's experiments.

The Principles of Mechanism. By Herbert A. Garratt. 166 5x7-inch pages, with 162 illustrations; Edward Arnold, London: Longmans, Green & Co., New York.

This short treatise discusses both the kinematics and the dynamics of machines. The first part takes up, under proper classification, mechanisms for transmitting and changing motions, pointing out in each case the method of obtaining the velocity ratio between the driving and the driven point, together with other subjects belonging with the study of mechanism. The second part includes a chapter on general principles, and then takes up in separate chapters the dynamics of the steam engine and of water motors.

The Design of Steel Mill Buildings. Second edition. By Milo S. Ketchum. 464 6x9-inch pages, with 189 illustrations and many illustrated problems. The Engineering News Publishing Company, New York. Price, $4.

This is an altogether admirable treatise and, moreover, one for which there is real need. While, as is to be expected, it discusses the strength of framed structures both graphically and analytically, it does much more than this, going fully into minor details of design, and containing numerous tables and diagrams which are new and extremely useful. No engineer or architect engaged in the design of mill buildings can afford to be without it, and the manufacturer who is not a civil engineer will find it full of information that he needs.

An Introduction to Eccentric Spiral Turning. By N. C. Robertson. 48 5½x9-inch pages, with 38 text cuts and 12 full-page plates. E. & F. N. Spon, London; Spon & Chamberlain, New York. Price, $2.

This book is intended for the large and honorable body of amateur mechanics which flourishes in England in a manner which we wish might be reproduced here. The book relates to one class of ornamental lathe work which it shows how to produce by the proper setting and manipulation of the chucks with which English amateur lathes are provided. The half-tone plates are reproduced from photographs of work executed in this manner, and that such forms can be produced on a lathe will come as a great surprise to most mechanics, no matter how experienced and skilful they may be in commercial work.

Self-Propelled Vehicles, by James E. Homans; 582 pages; 5½x8½ inches; 399 illustrations. Theo. Audel & Co., New York. Price, $2.

The fact that this book has reached a sixth edition indicates that it has met a demand for information along this line that is not covered by any other publication. In view of the fact that the gasolene motor has become the favorite driving power for vehicles of this kind, the author naturally devotes the most space to this kind of machine, showing how the motors are built, and how they are connected to the vehicle itself; and gives a large amount of information in regard to the handling and repairing of the various parts that are likely to go wrong. The electric and steam machines also receive attention, as well as the motor cycle, which is becoming popular in many sections. The book is very fully illustrated, and the index is complete enough so that there should be no difficulty in finding any particular bit of information without delay.

Experiences sur le Travail des Machines-Outils pour les Metaux, by C. Codron, engineer, professor at Institut Industriel du Nord. Second part. 552 pages, 8¼x10¾ inches; 1027 illustrations. H. Dunod and E. Pluat, éditeurs. Paris. Price, 25 francs.

This bulky volume is the second part of a work of which we reviewed the first part (treating on grinding, shearing and punching) at page 422, Vol. 26 (1903). This new part is devoted entirely to drilling and boring. At the beginning the elements of the action of drills are discussed, and the effect of various shapes of drills and boring tools is developed in minute detail, with the aid of many drawings and some mathematics. Sketches of chips from various metals are given by the score, with a discussion of the indications which they afford of the character of the metal and the condition of the tool. The force and power required for drilling under various conditions are subjected to a deep theoretical analysis with the aid of plenty of force diagrams, algebra, trigonometry and calculus, and the results for many different metals are brought into tabular form. This part of the subject is further developed by a section on the testing of drills and drilling machines, giving methods, and reports of many tests, and abounding in plotted curves for various pressures, speeds, etc. A work of such magnitude is useful chiefly for reference, but the lack of an alphabetical index is quite an impedimeint to its use in this manner. Perhaps it is the intention to prepare such an index when the whole work is completed; however, if other machines or processes, such as the lathe or milling machine, for instance, are to receive a treatment proportional to their importance on the same scale as have drilling and boring, we think it is certainly worth while to prepare a separate index for each part. There is a table of contents covering one page.

Practical Shop Work, by Carl S. Dow, editor-in-chief. 1352 pages; 7x10 inches. The Historical Publishing Company, Philadelphia; two volumes; $10.

It is difficult to give a satisfactory idea of a publication of this kind without going into greater details than is possible in the case. It is practically a compilation of a large amount of instructive material which has been published from time to time in various technical periodicals as well as in books, by the associate editors and contributors to this work. These are Oscar E. Perrigo, Edward R. Markham, Walter S. Leland, Henry M. Lane, John Lord Bacon, Howard E. Fairfield, William Neubecker, Victor Lougheed, and Harry G. Smith.

Many of the illustrations will be familiar to regular readers of this and other periodicals, as well as of some of the later books on mechanical lines, such as the "American Steel Worker," by Markham; "Shop Construction," by Perrigo; "Turning and Boring Tapers," by Colvin, and a number of others. This adds to rather than detracts from its value to the mechanic, as it is practically impossible to write or compile such a book without making use of similar sources of information, and the securing of such a vast amount of new matter would be practically out of the question, except at an enormous expenditure of time and labor.

It is a question as to the advisability of endeavoring to give a complete course of instruction in shop work, in mechanical drawing, in machine design, and even automobile construction, in such a work as this, as this seems to be more of an age for specializing along particular lines.

There are numerous illustrations throughout both volumes, most of them being in outline with a fair sprinkling of page half-tones illustrating various machine tools. Probably any mechanic can secure a great many practical points from these two volumes, but much of it is sure to be elementary to the machinist who has worked many years at his trade. Each section is followed by questions pertaining to it, after the manner of correspondence-school instruction.

From a stage coach type used in Limousin, a former province of middle France, comes the "Limousine" automobile body.

Box Tools for Small Taper Pins and Handles

By Tapers

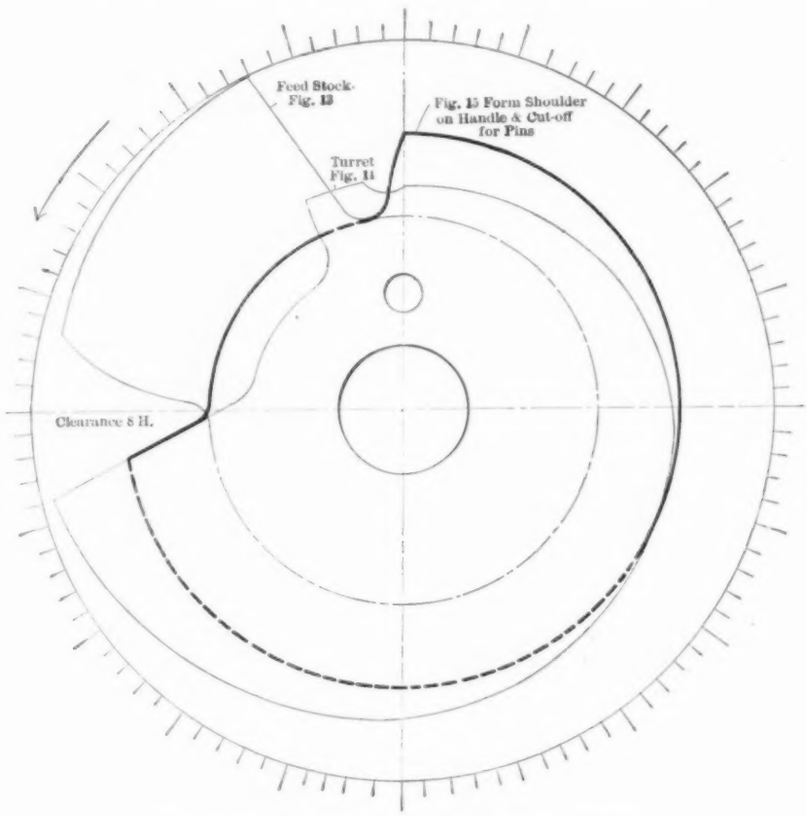
The accompanying sketches show a box forming tool, designed by the foreman of our screw department, to turn taper pins and irregular shaped pieces, such as shown full size at Fig. 12. The tool is used in any Brown & Sharpe machine No. 00 to No. 2 automatic.

The greatest trouble in making taper pins is to get them all alike, and a nice, smooth straight side, or uniform taper. What proved to be the great fault with all the devices which were tried, was the uneven cut and a "bellied" or convex side, as well as the variations in the diameters of the pins. After these faults were all found to exist, and were carefully noted, a tool was sought that had none of them. As none could be found on the market, one was designed and built, with the result that it has been in use nearly two years and has given entire satisfaction for turning pins from the smallest up to 5/16 inch diameter at the large end.

How it is Made

Fig. 1 shows four views of the tool assembled with the cutter in position. *A* is the box or body; *B* is the cutting-tool carriage or cross slide, which works across the box, and has a stud in the outer end *G*, which moves along the slide or stationary cam held in the tool-post of the machine. Slide *B* also has a stud *J*, which is screwed into the inner end and enters a hole located in the rear wall of the box. The spring *K* is compressed, and pushes against the stud *J* and the screw cap *H*, which is screwed into the outer end of the hole in the rear wall of the box *A*.

The cutting tool *E*, which is 3/16 inch square, can be of any desired brand of steel, and is held in place by the two set screws in the top of the slide *B*. Slide *B* also has a stop pin *I*, which is located in the under side of the slide near the outer end, and which extends down into an elongated hole, the length of which limits the travel of the slide across the box. The shank of the box is made ⅝ inch diameter by 2¼ inches long, and has a 5/16-inch hole drilled clear through to allow the making of extra long pins.



FIGS. 13, 14, 15. CAMS FOR TAPER PINS AND HANDLES

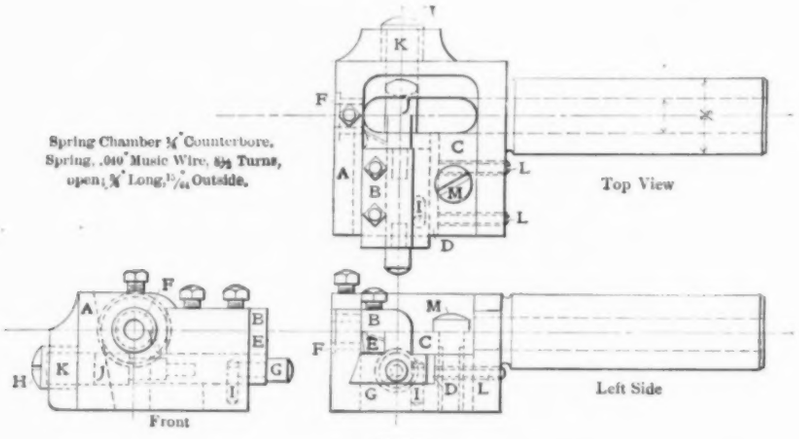


FIG. 1

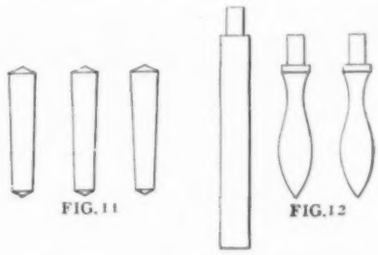
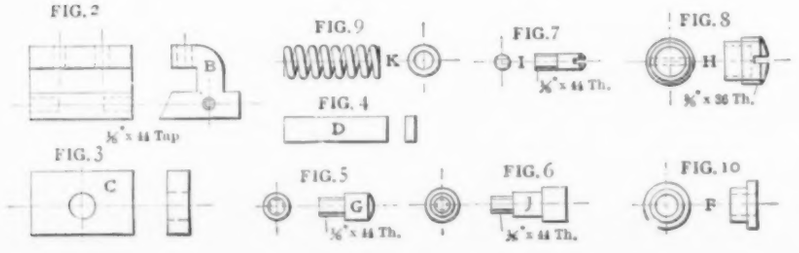


FIG. 11 FIG. 12

TAPER PINS AND HANDLES, FULL SIZ



BOX TOOLS FOR TAPER PINS

Guiding the Work

The front or working end of the box contains a 5/16-inch hole drilled in line with the hole through the center of the shank, and a set screw located in the upper edge to hold bushings, of different-sized holes, in place, to serve as guides in holding the stock central and steady while being formed. These bushings are made with holes 0.0005 inch larger than the diameter of the stock being

used, which insures the work being held firmly while the tool is cutting.

The screw *M* clamps the plate *C* in position to hold the gib *D* and the slide *B* in position, the lost motion being taken up by the gib screws *L L*. A flat strip with a straight edge may be clamped in the tool-post, with the edge at any angle desired, and in such a manner as to allow the stud *G* to work against the edge as the box is being moved forward by the turret. As the spring *K* keeps the slide *B* out, the tool must travel toward the center as it moves forward, thus starting the large end of the taper pins first.

After the pin is formed, the tool backs off and the rear tool-post advances with the cutting-off tool, which also rounds the ends or chamfers the corners. The pins shown at Fig. 11 are a size that is used in pinning small hubs and shafts together, and are made at the rate of about 1800 per 10 hours with as little trouble as straight pins.

Making Small Brass Handles

The two handles shown at Fig. 12 are of brass rod and are formed and cut off by this box tool, the stud end being formed by the rear tool in the tool-post of the machine, the front tool-post holding

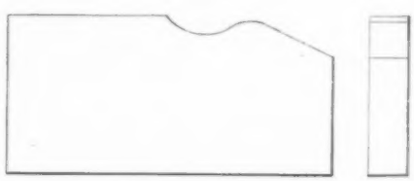


FIG. 16. CAM OPERATING SLIDE B

the pattern or flat cam which actuates the slide *B*. See Fig. 16. The handles are cut off at the sharp end. The straight piece shown at the left of Fig. 12 is the last end of the bar, and has at the upper end the stud formed ready to have the box tool shape the handle. The cutting tool used for forming pieces like those shown at Fig. 12 should have enough clearance to allow the cutting to be done by the extreme point of the tool. The cam and stud *G* should also be carefully formed so as to get the shape desired on the work.

The cams used in operating the turret and cutting-off tool for making the taper pins are shown at Figs. 13, 14 and 15. Fig. 13 is the cam for feeding the stock; Fig. 14 is the cam for operating the turret; Fig. 15 is the cam for operating the rear tool-post.

Information Wanted

One of our subscribers desires to obtain information regarding the methods used for removing the burs left by the slotting saw when milling the screwdriver slot of small, headless screws.

Help Wanted—Help Given

By Egypt

I read your "Help Wanted" editorial at page 260 with great interest and think it only fair to the American Machinist to say the title should have been "Help Wanted and Given."

Help given does in no way refer to the monetary side of the affair, for, as I view it, that is only incidental to the true gain that one gets from writing for such a paper.

The easiest way to find how little you know about a particular subject or thing is to endeavor to write about it. Unqualifiedly, I believe this to be true. How many of us have started to describe some little thing only to discover that at some point we must do a little investigating before we could go ahead! In description of principle or fact we must get the successive steps in their proper sequence and true relation if our ideas are to be conveyed logically to the reader or before they will "sound right" to us when we read them. So I believe that whether our subject be a chicken-coop or a 10,000-horse-power plant we know more about it after we have described it than we did before; our ideas are clearer, more logically formed. This is no new principle; it is applied in every school and college today and why is it not as applicable here?

But the greatest benefit derived is that of the interest stimulated by writing. If we get into the habit of describing things about the shop our interest grows, our knowledge broadens. If our story about a special chuck is published we inadvertently feel a pride in it, and want to see what the other fellows are saying and so we read more and our interest broadens.

Someone's description of a milling fixture may have helped you out of a hole; so you want to give other readers anything you have "up your sleeve" in return. And so you gradually obtain the power of *seeing* things, not just *looking* at them.

When you *see* a thing you take in its principles of operation; they are lastingly impressed upon your brain and you can use and apply them in similar places. For a developer of seeing power commend me to the necessity for a description of an appliance or process after we have come in contact with it.

"Mac's the best foreman we ever had," said the superintendent as I was walking with him through a section of his shop. I understood later, when I asked, "may I describe that tapping fixture and drill press attachment for the American Machinist"? The superintendent smiled. "You are too late," he said, "Mac wrote those things up long ago, and I believe he got 5 or 10 dollars out of them." Mac and the superintendent may have thought that the money was all Mac got out of his articles, but I believe it was quite largely because he happened to get started writing up little things which were published and so gradually developed his interest that he became wide-awake and developed into the "best foreman we ever had."

Every foreman, no matter how large or small his shop, has done something that is worth telling about. How much better it would be for him if he would not stop at developing the idea but would write it up for publication and in so doing stamp its principles upon his mind and at the same time develop his receptive powers and become on the alert for someone else's ideas that he can apply to his own work

If I were superintendent of a shop I would encourage my foreman to do these things by offering a bonus for each article published, in proportion to the amount the publisher paid.

Will not "Entropy," "Osborne," "Dixie" and other contributors to the American Machinist agree with me that they are broader minded, quicker to grasp ideas and better able to apply them, because of their writing and the interest created by their doing so?

Business Items

Clinton E. Hobbs, manufacturers' agent, of Boston, Mass., has removed to his new office, room 28, 12 Pearl street.

The Star Corundum Wheel Company, Detoit, Mich., are now located in their new factory 241-251 Calvary Avenue.

The Wilmarth & Morman Company, Grand Rapids, Mich., report that shipments of their product during February exceeded, with one exception, that of any other month in the company's history.

The Bullard Machine Tool Company, Bridgeport, Conn., has appointed the Pacific Tool and Supply Company, 556 Howard street, San Francisco, Cal., agents for their product in California.

The Yale & Towne Manufacturing Company has recently awarded to Frank B. Gilbreth, New York, contracts for building extensions to their press shop and cabinet lock department at Stamford, Conn.

The Smith Countershaft Company, of Boston, Mass., manufacturers of the well known Smith one-belt reversing countershafts, report that they have received an order to equip the entire new plant of the Otis Elevator Company, at East Buffalo, with their countershafts.

Chas. H. Besly & Co., 15 South Clinton street, Chicago, Ill., have been advised by the Department of State, Washington, D. C., that they have been awarded medals on their exhibit of Besly disc grinders and Besly band polishing machines at the Leige Exposition.

Manufacturers

The Westcott Chuck Company, Oneida, N. Y., will build an addition.

The Cleveland (Ohio) Electric Illuminating Company will erect an addition.

The American Wringer Company, Woonsocket, R. I., will enlarge its plant.

The Federal Brass and Bronze Company, of New York, will erect a factory in Astoria, L. I.

McCann Brothers, Philadelphia, Penn., are having plans prepared for an ice-making plant.

The city of Fremont, Neb., has voted $50,000 to build a new municipal water and light works.

The power plant of the Huntsville (Ala.) Railway, Light and Power Company will be doubled.

The Woven Steel Hose and Rubber Company, Trenton, N. J., has purchased site for a new plant.

The Crittenden Roofing and Manufacturing Company, Minneapolis, Minn., will build a new plant.

The F. M. Shaffer Ice Company, Johnstown, Penn., will erect a $60,000 plant for the manufacture of ice.

Plans are being prepared for a large addition to the plant of the Locomobile Company, Bridgeport, Conn.

The Winchester Repeating Arms Company, New Haven, Conn., has filed application for the erection of new buildings.

The Armor Steel and Foundry Company, now operating a plant at Matthews, Ind., will erect a large plant in Joliet, Ill.

The George H. Smith Steel Casting Company, Milwaukee, Wis., will erect a new foundry to cost about $25,000.

The Corn Products Refining Company are building an immense plant, consisting of forty odd buildings at Summit, Ill.

The shop of A. J. Machek, manufacturer of bench shears, fine tools and instruments, Milwaukee, Wis., was destroyed by fire.

Charles Sumner Cook, of Portland, Me., and others, will erect a power plant on the Androscoggin river, near Brunswick.

The Barnett Drop Forge Company, Easthampton, Mass., whose plant recently burned, will rebuild at once on a larger scale.

The Straub Machinery Company, Cincinnati, Ohio, will erect a new factory, also foundry, at a cost of about $100,000.

Ground is being broken for the new $2,000,000 machine shops to be built for the Lackawanna Railroad in Scranton, Pa.

The Canadian General Electric Company has found it necessary to erect another machine shop at its plant in Peterboro, Ont.

The Portland (Ore.) Railway, Light and Power Company, will build another plant with a capacity of 25,000 horse-power.

The International Harvester Company has started the construction of a new $500,000 furnace at its plant in South Chicago, Ill.

A new addition is being built to the plant of the Abrasive Material Company, Philadelphia, Penn., to be used as a turning shop.

The Missouri Lead and Zinc Company, Joplin, Mo., will install new machinery and extend its power house, expending about $25,000.

The Stanley Works Company, of New Britain, Conn., will erect a large power house in Kent, from which it will derive power for its plant.

The plant of the Wire and Telephone Company, Rome, N. Y., was destroyed by fire. Loss, $200,000. It will be rebuilt immediately.

The Barlow Manufacturing Company, Holyoke, Mass., is planning to build a new factory to manufacture nickel and brass display fixtures, etc.

The Standard Malleable Iron Works, Muskegon, Mich., is building an addition to its plant. When completed, 100 more men will be employed.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Cox Computers, 75 Broad St., New York.

Caliper catalog free. E. G. Smith Co., Columbia, Pa.

Universal Test Indicator circulars free. H. A. Lowe, Lock Box 146, Cleveland, O.

Will buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Light fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Special machinery accurately built. Screw machine and turret-lathe work solicited. Robt. J. Emory & Co., Newark, N. J.

Manufacturers to take the manufacture of a compound simple engine on royalty basis. We invite your investigation. Box 732, AM. M.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

Arrange with us to do your manufacturing; we build special machinery, special tools, etc. Lewis Blind Stitch Machine Company, 502 North Commercial St., St. Louis, Mo.

Advice—Mechanical, both practical and technical. Tell me your needs. I'll tell you the cost. Results or no fee. Jos. V. Woodworth, M. E., Arbuckle building, Brooklyn, N. Y., U. S. A.

A large English firm of machine-tool importers, having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Isaac B. Owens, patent attorney, 100 Broadway, New York City, specialist in oil and gas engines, automobiles and automatic machinery. Patent applications entrusted to me will receive careful, personal attention, and patents secured which will protect.

Successful draftsmen drawing $125 to $200 monthly require thorough drafting room knowledge. As chief draftsman of engineering firm I know exactly the quality and quantity of experience and practical training you must have, and prepare you by mail, home instructions for above paying positions, which I furnish free anywhere. Complete highest grade drawing outfit, with German silver set of tools, value $13.85, free. Address Chief Draftsman, Div. 4, Eng.'s Equip't Co., (Inc.), Chicago.

We can build machinery for quick delivery. A shop building machine tools wishes to take contracts for the construction of machinery or anything that can be produced in a foundry and machine shop. Send drawings and specifications and estimates will be made with guarantee of quick delivery. We can refer to a standard line of tools now on the market as to the quality of workmanship. Box 75, AMERICAN MACHINIST.

Wanted—A good superintendent capable of handling pattern shop, foundry and machine shop departments in a general jobbing, repairing and manufacturing shop located in a rapidly growing city of two hundred thousand inhabitants, center of a big lumbering country in the West; one who could invest about $10,000 preferred, an excellent opening for the right man. Full investigation demanded and given. Address Box 692, AMER. MACH.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Designer, graduate of university, with six years' practical shop and drawing room experience in machine tools and jigs desires position preferably as assistant superintendent. Box 722, AMERICAN MACHINIST.

ILLINOIS

Mechanical draftsman, with 6 years' shop practice, 2 years' technical education, 2 years' drafting room experience, wants to change. Address Box 746, AMER. MACH.

MASSACHUSETTS

A young man desires a position as a designer on jigs and tools; prefers cotton machinery; over 10 years' shop experience; considerable inventive ability; temperate. Address Box 711, AMERICAN MACHINIST.

NEW JERSEY

Master mechanic, designer on special automatic machines, tools; competent organizer and superintendent; references. Box 738, AMERICAN MACHINIST.

A factory man with all-around office experience, costs, time keeper and general shop routine, desires to locate with a manufacturing concern. Box 741, AMER. MACHINIST.

Salesman with established trade, machinery, tools, specialties, etc.; 10 years on the road throughout Great Britain, invites correspondence with first-class firm desiring representation; at present employed in the United States. Box 747, AMER. MACH.

NEW YORK

Mechanical draftsman, 7 years' general experience, desires position. Box 737, AM. M.

Mechanical engineer, graduate; age 26, 3 years' experience, desires change. Box 740, AMERICAN MACHINIST.

Experienced mechanical draftsman desires position in New York City or neighborhood. Box 709, AMERICAN MACHINIST.

Draftsman, experienced designer on special and general machinery; New York or New Jersey preferred. Box 726, AMER. MACH.

All-around factory office and cost man desires executive position with manufacturing concern; highest credentials. Box 739, AM. M.

Position as works manager of foundry and machine shop, also purchasing of materials for same and cost reviser; fifteen years' experience, highest references. Address Box 736, AMERICAN MACHINIST.

Position as superintendent of machine shops; accurate, interchangeable commercial work; married man with first-class reference; character and ability open. Address Box 689, AMERICAN MACHINIST.

Works manager or superintendent; business, technical and mechanical training; familiar with manufacturing methods; several years' experience as executive; location, unimportant. Box 723, AMERICAN MACHINIST.

Position as manager of works; held similar position seven years; can improve and design machinery; good mechanical, executive and business abilities; furnish best of references from concern where now employed. Box 374, AMERICAN MACHINIST.

Iron foundry superintendent or foreman is open to immediate engagement; loam, dry and green sand; capable of handling large force; well up in cupola practice, mixing by analysis, heavy and light machinery; temperate, economical; first-class references. Address Box 719, AMERICAN MACHINIST.

OHIO

Situation wanted by a man of a wide range of experience; resourceful in methods and capable of securing the maximum of results from mechanical efforts as applied to manufacturing; initiative by disposition, but not averse to subordinate positions. Address "M. R. C.," AMERICAN MACHINIST.

PENNSYLVANIA

Mechanical engineer of ten years' experience on German railway, also one year as draftsman in steel car company, having some knowledge of civil engineering, desires position on southern railway. Box 735, AM. M.

As assistant superintendent with firm manufacturing forgings, drop forgings, etc. Technical graduate; (27); 6 years' practical experience; well posted modern cost keeping system, design of dies, tools, etc. Plant, Chicago district preferred. Box 720, AM. M.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Wanted—First-class operator on Jones & Lamson turret lathe; also one first-class all-around machinist. The New Machine Co., Danbury, Conn.

ILLINOIS

Wanted—Several first-class vise and floor men accustomed to heavy machine tool work; steady employment and good wages. Box 685, AMERICAN MACHINIST.

Wanted—Working foreman to handle ten to twenty men on erecting heavy machine tools; good wages for right party; married man preferred. Box 684, AMERICAN MACHINIST.

Representative wanted in New York City—Man to handle, on commission basis, sheet metal line; have already an established business, but desire to increase it; can be handled satisfactorily by live manufacturer's agent. Address Box 717, AMERICAN MACHINIST.

INDIANA

Wanted—Ten good lathe men; increasing force; good wages; steady employment. Western Motor Co., Logansport, Ind.

MASSACHUSETTS

Wanted—Experienced draftsmen on tool design, shop equipment, structural work, valve design, and miscellaneous; also tracers. Apply by letter to Walworth Mfg. Co., South Boston, Mass.

Wanted—Assistant mechanical draftsman, one used to shop methods and gear cutting preferred; state age, experience and wages expected, Address Boston Gear Works, Norfolk Downs, Mass.

General machine shop foreman, by established, growing company building strictly high-grade grinding machinery and employing about 100 hands; must be thoroughly up to date in methods, successful in handling men, and able to produce first-class work at reasonable cost; other things equal, preference will be given man with experience in grinding machines or first-class machine tools. Write fully as to experience, age, salary expected and present position; confidential if desired. Box 742, AMER. MACH.

MICHIGAN

Wanted—Sub-foreman to take charge of testing small steam engines; must be used to indicator work. Address Box 728, AM. M.

Wanted—One competent draftsman for hull work; one experienced draftsman for gasolene engine work; permanent positions for the right men. Address Racine Boat Mfg. Company, Muskegon, Mich., or call at our stores in New York, Camden, Boston, Chicago or Detroit.

MISSOURI

Wanted—First-class adjusters accustomed to adding machine and typewriter work. Universal Adding Machine Co., St. Louis.

Wanted—Draftsman experienced in presses, dies and sheet metal tools; state if experienced in getting up catalogs and selling goods. The Fred J. Swaine Mfg. Co., St. Louis, Mo.

Wanted—Competent toolmaker for gas engins jigs and templates; no die sinker or jeweller, just good all around, accurate machinist; shiftless men need not apply. Witte Iron Works Co., Kansas City, Mo.

Wanted—Assistant to president and manager; a good buyer and office man; who has had a practical training in building gas and gasolene engines and knows how to handle details; salary $1200 up; communications confidential. Witte Iron Works Co., Kansas City, Mo.

Draftsman Wanted—Large lead mining company, 65 miles south of St. Louis, Missouri, wants draftsman for mechanical drafting and for making surface and underground maps; must be first-class freehand letterer and neat workman; man with knowledge of plotting and calculating survey field notes preferred; applicants please submit specimens of work and state salary wanted. Box 743, AMERICAN MACHINIST.

NEW JERSEY

Wanted—Salesmen to take new tool as side line; good seller; liberal commission. State experience, territory now working in, and lines carried. Address Box 367, Newark, N. J.

Wanted—Tool, die and instrument makers accustomed to accurate, complicated work; steady work and good wages to thoroughly competent men; give references. Address Box 438, AMERICAN MACHINIST.

We are increasing our tool-making department and solicit applications from toolmakers and machinists who are experienced on fine and complicated work. Apply to Victor Talking Machine Co., Camden, N. J.

We have increased our plant and desire floor and vise hands for day work and lathe hands for night work. Good pay and steady work for good men. Address or apply at Pond Machine Tool Co., Plainfield, N. J.

NEW YORK

Pattern shop foreman, desires change; experienced on both large and small work; references, Box 733, AMERICAN MACHINIST.

Wanted—Competent foreman to direct machine tool work in shop building steam engines. Address Box 734, AMER. MACHINIST.

Wanted—Experienced draftsmen, toolmakers and machinists; give age, references and wages expected. Remington Arms Co., Ilion, N. Y.

Wanted—A mechanical draftsman; must be a good detailer; state experience, reference and salary desired. Address Box 745, AMERICAN MACHINIST.

Wanted—Expert tool designers for die, jig and fixture work; also competent men for experimental drafting; positions permanent to competent men. Address Box 744, AM. M.

Foreman for machine shop, must be thoroughly competent and experienced in general machinery construction; good opening for active and hustling man. Box 729, AM. M.

Wanted—Several first-class mechanical and electrical draftsmen. Apply, giving age, experience and salary expected to Engineer in Charge, Drafting Department, General Electric Company, Schenectady, N. Y.

Wanted—First-class man thoroughly familiar with all kinds of tool work, one capable of handling help and filling position of responsibility. State age, experience and salary expected. Box 725, AMER. MACHINIST.

A small, growing manufacturing concern has a good position open for an all-around hustler to act as working foreman; state age, experience in detail, and salary expected. Young married man preferred. Address Box 731, AMERICAN MACHINIST.

Screw machine foreman wanted to take charge of about twenty hand screw machines, steady job assured to a person combining both the mechanical and executive skill for producing high-grade output in steel; location, New York City. Address Box 727, AM. M.

Wanted—First-class tool, jig and fixture designer, who can design appliances for facilitating the construction and the assembling of automobiles, and at the same time maintain a high degree of accuracy and first-class workmanship. Address Box 724, AM. M.

OHIO

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Chisels, Cold
Hammacher, Schlemmer & Co., New York.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Chucking Machines
American Tool Wks. Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Mach. Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, Ohio.
Potter & Johnston Mach. Co., Pawtucket, R. I.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.
Windsor Mach. Co., Windsor, Vt.

Chucks, Drill
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Brown Co., R. H., New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Horton & Son Co., E., Windsor Locks, Conn.

Chucks, Drill—*Continued.*
Jacobs Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Niles-Bement-Pond Co., New York.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Standard Tool Co., Cleveland, O
Trump Bros. Mach. Co., Wilmington, Del.
Wells Bros. Co., Greenfield, Mass
Whitney Mfg. Co., Hartford, Ct.
Whiton Mach. Co., D. E., New London, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Chucks, Lathe
Cushman Chuck Co., Hartford, Conn.
Gisholt Mach. Co., Madison, Wis
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Son Co., E., Windsor Locks, Conn.
Niles-Bement-Pond Co., New York
Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Ct.
Whiton Mach. Co., D. E., New London, Conn.

Chucks, Planer
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.

Chucks, Split
Rivett Lathe Mfg. Co., Boston, Mass.

Circuit Breakers
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps
Billings & Spencer Co., Hartford, Conn.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Tudor Mfg. Co., Worcester, Mass.

Clutches, Friction
Caldwell, Son & Co., H. W., Chicago, Ill.
Cresson Co., Geo. V., Phila., Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newtonn Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Wood's Sons Co., T. B., Chambersburg, Pa.

Clutches, Magnetic
Electric Controller & Supply Co., Cleveland, Ohio.

Coal Handling Machinery
Link-Belt Co., Philadelphia, Pa.

Coils
Standard Welding Co., Cleveland, Ohio.

Collectors, Pneumatic
Sturtevant Co., B. F., Boston, Mass.

Compound, Pipe Joint
Dixon Crucible Co., Joseph, Jersey City, N. J.

Compound, Slushing
Warren Bros. Co., Boston, Mass.

Compressors, Air
Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Boston, Mass.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas
Ingersoll-Rand Co., New York.

Conduit, Interior
Sprague Electric Co., New York.

Cones, Friction
Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps
Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work
Blanchard Mach. Co., Boston, Mass.
Chapman & Co., J. B., Springfield, Mass.
Skinner Ship Bldg. & Dry Dock Co., Baltimore, Md.
Turner Mach. Co., Danbury, Conn.

Controllers and Starters, Electric Motor
Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic
Lamson Consol. S. S. Co., Boston, Mass.
Link-Belt Co., Philadelphia, Pa.

Coping Machines
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Cork Inserts
National Brake & Clutch Co., Boston, Mass.

Corundum
See Grinding Wheels

Cost Systems
American Mechanical Calculator Co., Cincinnati, O.

Cotters
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.

Countershafts
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders' Iron Fdry., Prov., R. I.
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Mossberg Wrench Co., Central Falls, R. I.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction
Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing
Cresson Co., Geo. V., Phila., Pa.
Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Counters, Machinery
Veeder Mfg. Co., Hartford, Conn.

Couplers, Hose
Ingersoll-Rand Co., New York.

Couplings, Shaft
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.

Couplings, Shaft—*Continued.*
Chisholm & Moore Mfg. Co., Cleveland, O.
Cresson Co., Geo. V., Phila., Pa.
Electric Controller & Supply Co., Cleveland, Ohio.
Link-Belt Co., Philadelphia, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.
Wood's Sons Co., T. B., Chambersburg, Pa.

Cranes
Alliance Machine Co., Alliance, O.
Brown Hoisting Mach. Co., Cleveland, Ohio.
Case Mfg. Co., Columbus, O.
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Maris Bros., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
United Engineering & Fdry. Co., Pittsburg, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines
Niles-Bement-Pond Co., New York.
Underwood & Co, H. B., Philadelphia, Pa.

Crank Shafts
Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles
Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas, and Ladles, Foundry
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups and Covers, Oil
Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.
Winkley Co., Detroit, Mich.

Cups, Grease
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cutters, Milling
Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Boker & Co., Hermann, New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Nash Company, Geo., New York.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines
Armstrong Bros. Tool Co., Chicago, Ill.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Hill, Clarke & Co., Inc., Boston, Mass.
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Newton Mach. Tool Works, Philadelphia, Pa.
Nutter, Barnes & Co., Boston, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Fairbanks Co., Springfield, Ohio.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.

Cyclometers
Veeder Mfg. Co., Hartford, Conn.

Diamond Tools
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.

Dies, Sheet Metal
American Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Kent & Co., Edw. R., Chicago, Ill.
Mossberg Wrench Co., Central Falls, R. I.
Wade Machine Co., Boston, Mass.

Dies, Sub-Press
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Opening
Baker, S. S., Chicago, Ill.
Boker & Co., Hermann, New York.
Errington, F. A., New York.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Mach. Co., Springfield, Vt.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins
Winkley Co., Hartford, Conn.

Drawing Boards and Tables
Alteneder & Son, Theo., Philadelphia, Pa.
Economy Drawing Table Co., Toledo, Ohio.
Mittineague Paper Co., Mittineague, Mass.
Soltmann, E. G., New York.

Drawing Materials
Alteneder & Son, Theo., Philadelphia, Pa.
American Tracing Cloth Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Soltmann, E. G., New York.
Technical Supply Co., Scranton, Pa.

Drafting Machines
Universal Drafting Mach. Co., Cleveland, O.

Drift Bolt Drivers
Ingersoll-Rand Co., New York.

Drilling Machines, Bench
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Dwight Slate Mach. Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Ingersoll-Rand Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Boiler
American Tool Wks. Co., Cin., O.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, Ohio.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Electric
Chicago Pneumatic Tool Co., Chicago, Ill.

Drilling Machines, Multiple Spindle
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co. B. F., Rockford, Ill.
Barnes Co. W. F. & John, Rockford, Ill.
Baush Mach. Tool Co. Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Fenn Mach. Co., Hartford, Conn.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Harrington Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.

Drilling Machines, Portable
Cincinnati Elec. Tool Co., Cin., O.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial
American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Detrick & Harvey Mach. Co., Baltimore, Md.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Fdry. Co., Jno. B., Cincinnati, O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

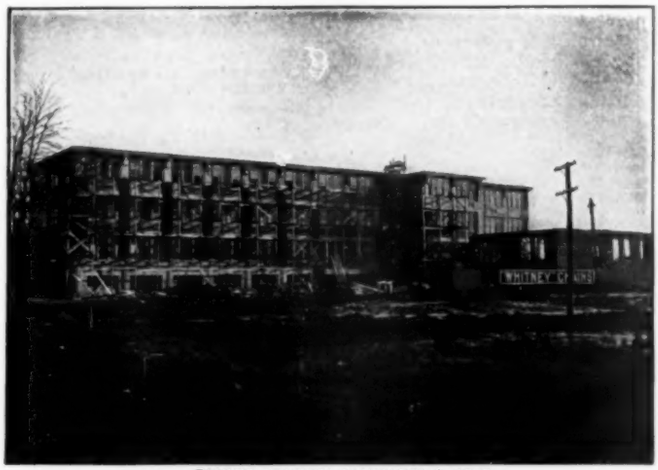
Drilling Machines, Turret
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright
American Tool Wks. Co., Cin., O.
Baker Bros, Toledo, O.
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co., Cincinnati, O.

"Whitney" Chains

In 1907 will break all previous records for durability

We are moving into our new fire-proof factory building and will operate both plants, old and new, until we are fully settled so our production may be steadily increased with no interruption.



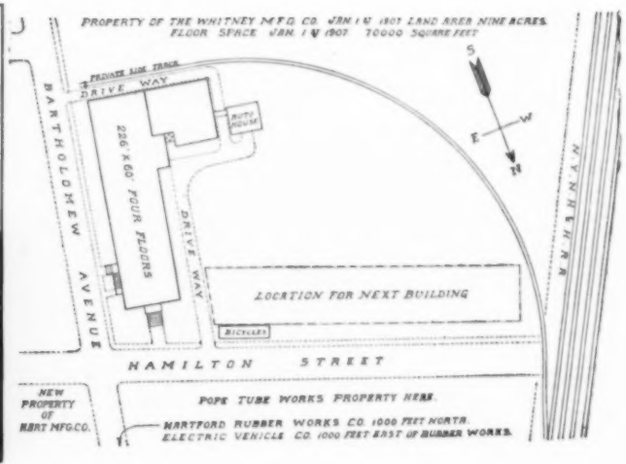
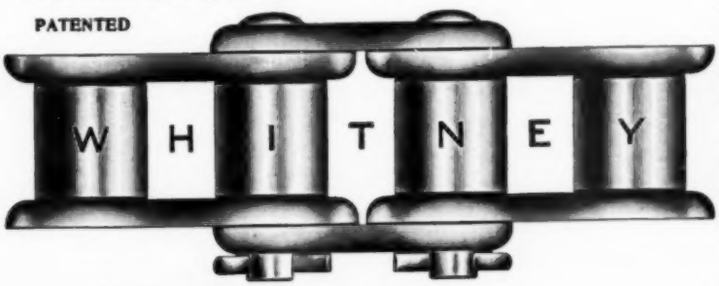
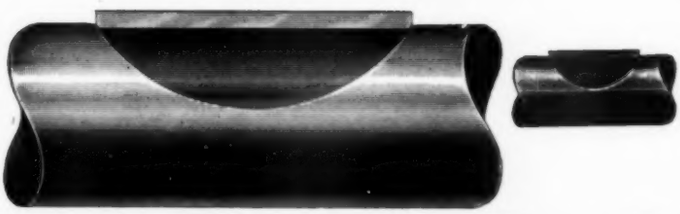
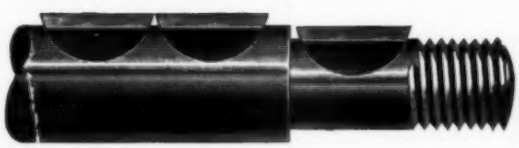


PHOTO. TAKEN JANUARY 6 1907

This cut gives an idea only of the plant which we believe will be the finest and most complete in existence for the manufacture of High Grade Driving Chains.







"Whitney" Chains

HAND AND WEIGHT FEED MILLING MACHINES, and The Woodruff Patent System of Keying

are Standard with most American Builders of Automobiles, Commercial Cars, Machinery, etc.

The Whitney Mfg. Co.
Hartford Connecticut

Drilling Machines, Upright —*Continued.*
Fenn Mach. Co., Hartford, Conn.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, Ohio.
Knight Machry. Co., W. B., St. Louis, Mo.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Ct.
Wells Bros. Co., Greenfield, Mass.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Drills, Center
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand
Cincinnati Electrical Tool Co., Cincinnati, O.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.

Drills, Rail
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Foote-Burt Co., Cleveland, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Hisey-Wolf Mach. Co., Cincin., O.
Keystone Mfg. Co., Buffalo, N. Y.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

Drills, Rock
Ingersoll-Rand Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.

Drying Apparatus
Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos
Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
Eck Dynamo & Motor Works, Belleville, N. J.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. Co., Chicago, Ill.
Sprague Elec. Co., New York.

Dynamos—*Continued.*
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincin., O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrical Supplies
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Elec. Co., New York.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrically Driven Tools and Machinery
American Tool Wks. Co., Cin., O.
Cincinnati Electrical Tool Co., Cincinnati, O.
Crescent Forgings Co., Oakmont, Pa.
Electric Controller & Supply Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cincin., O.
Lincoln Motor Wks. Co., Cleveland, O.
Ransom Mfg. Co., Oshkosh, Wis.
Roth Bros. Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.

Elevators
Albro-Clem Elevator Co., Philadelphia, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.
Morse, Williams & Co., Phila., Pa.

Emery Wheels
See Grinding Wheels

Emery Wheel Dressers
American Emery Wheel Co., Providence, R. I.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Heald Machine Co., Worcester, Mass.
International Specialty Co., Detroit, Mich.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

Enclosures, Tool-room
Hart & Cooley Co., New Britain, Conn.
Merritt & Co., Philadelphia, Pa.

Engineering Appliances
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Engineers, Consulting and Mechanical
Dodge & Day, Philadelphia, Pa.

Engineers, Electrical
Crocker-Wheeler Co., Ampere, N. J.
Dodge & Day, Phila., Pa.

Engines, Automobile
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Olds Gas Power Co., Lansing, Mich.

Engines, Gas and Gasolene
Automatic Mach. Co., Bridgeport, Conn.
Blaisdell Machinery Co., Bradford, Pa.
Foos Gas Engine Co., Springfield, Ohio.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Jacobson Mach. Mfg. Co., Warren, Pa.
New Era Gas Engine Co., Dayton, O.
Olds Gas Power Co., Lansing, Mich.
St. Marys Mach. Co., St. Marys, Ohio.
Struthers-Wells Co., Warren, Pa.

Engines, Steam
Buffalo Forge Co., Buffalo, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Engravers
Bormay Engraving Co., New York.
Standard Engraving Co., New York.

Engraving Machinery
Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads
Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition Machinery
Machinery Exchange, Boston, Mass.
Philadelphia Bourse, Phila., Pa.

Expanders, Tube
Nicholson & Co., Wm., Wilkes-Barre, Pa.

Facing Machines, Portable
Underwood & Co., H. B., Philadelphia, Pa.

Factory Equipment
Lyon Metallic Mfg. Co., Aurora, Ill.

Fans, Electric
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust
Buffalo Forge Co., Buffalo, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Feathers
Standard Gauge Steel Co., Beaver Falls, Pa.

Files and Rasps
American Swiss File & Tool Co. New York.
Barnett Co., G. & H., Phila., Pa.
Hammacher, Schlemmer & Co., New York.
Nicholson File Co., Prov., R. I.
Reichheim & Co., E. P., New York.

Filler, Iron
Felton, Sibley & Co., Phila., Pa.

Filing Machines
Cochrane-Bly Co., Rochester, N. Y.
Detrick & Harvey Mach. Co., Baltimore, Md.
Henry & Wright Mfg. Co., Hartford, Conn.
Simplex Mfg. Co., New York.

Flexible Shafts
Chicago Flexible Shaft Co., Chicago, Ill.
Coates Clipper Mfg. Co., Worcester, Mass.

Forges
Boynton & Plummer, Worcester, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Buffalo Forge Co., Buffalo, N. Y.
Ingersoll-Rand Co., New York.
Miner & Peck Mfg. Co., New Haven, Conn.
Prentiss Tool & Supply Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Forgings, Drop
Bethlehem Steel Co., So. Bethlehem, Pa.
Billings & Spencer Co., Hartford, Conn.
Crescent Forgings Co., Oakmont, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Page-Storms Drop Forge Co., Springfield, Mass.
Wyman & Gordon Co., Worcester, Mass.

Forgings, Hydraulic
Bethlehem Steel Co., So. Bethlehem, Pa.
Wyman & Gordon Co., Worcester, Mass.

Forgings, Machine
Dyson & Sons, Jos., Cleveland, O.

Forgings, Steel
Baldwin Steel Co., New York.
Bethlehem Steel Co., So. Bethlehem, Pa.
Crescent Forgings Co., Oakmont, Pa.
Heppenstall Forge & Knife Co., Pittsburg, Pa.
Kent & Co., Edwin R., Chicago, Ill.
McInnes Steel Co., Corry, Pa.
Tindel-Morris Co., Eddystone, Pa.
Wyman & Gordon Co., Worcester, Mass.

Foundry Furnishings
Adams Co., Dubuque, Iowa.
Ingersoll-Rand Co., New York.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Fuel Economizers
Sturtevant Co., B. F., Hyde Park, Mass.

Furnaces, Annealing and Tempering
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Tate, Jones & Co., Pittsburg, Pa.

Furnaces, Enameling
American Gas Furnace Co., New York.

Furnaces, Gas
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Obermayer Co., S., Cincinnati, O.
Westmacott, J. M., Prov., R. I.

Furnaces, Melting
American Gas Furnace Co., New York.
Nash Company, Geo., New York.
Turner Brass Works, Chicago, Ill.

Furnaces, Oil
Tate, Jones & Co., Pittsburg, Pa.

Furniture, Machine Shop
Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.
Manufacturing Equip. & Engineering Co., E. Boston, Mass.
Merritt & Co., Philadelphia, Pa.
New Britain Mach. Co., New Britain, Conn.

Gas Blowers and Exhausters
Sturtevant Co., B. F., Hyde Park, Mass.

Gages, Recording
Bristol Co., Waterbury, Conn.

Gages, Standard
Brown & Sharpe Mfg. Co., Providence, R. I.
Henry & Wright Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Gages, Steam
Crosby Steam Gage & Valve Co., Boston, Mass.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gear Cutting Machinery
Adams Co., Dubuque, Iowa.
Bair & Gazzam Mfg. Co., Pittsburg, Pa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Bilgram, Hugo, Philadelphia, Pa.
Brown & Sharpe Mfg. Co., Providence, R. I.
Clough, R. M., Tolland, Conn.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant-Lees Mach. Co., Cleveland, Ohio.
Harrington, Sons & Co., Edwin, Philadelphia, Pa.

The Washington Naval Gun Factory—IX

The Miscellaneous Shop, Where the Fine Work on Sights and Mounts Is Done—The Tool Shop—Pay and Working Hours, etc.

BY HENRY J. KENNEDY

The "miscellaneous shop for ordnance" is the one next north of the secondary-mount shop, being divided from it by Tingey street; in this shop is done a similar class of work, including gun mounts and various small work. The building, which was completed in 1902, is of brick and is of the same size as the secondary-mount shop, that is, 65 feet 2 inches by 251 feet. Including day and night shifts, about 300 men are employed in this shop. A great deal of the work is on 3-inch and 4-inch guns, of various lengths, and parts of six-pounder sights.

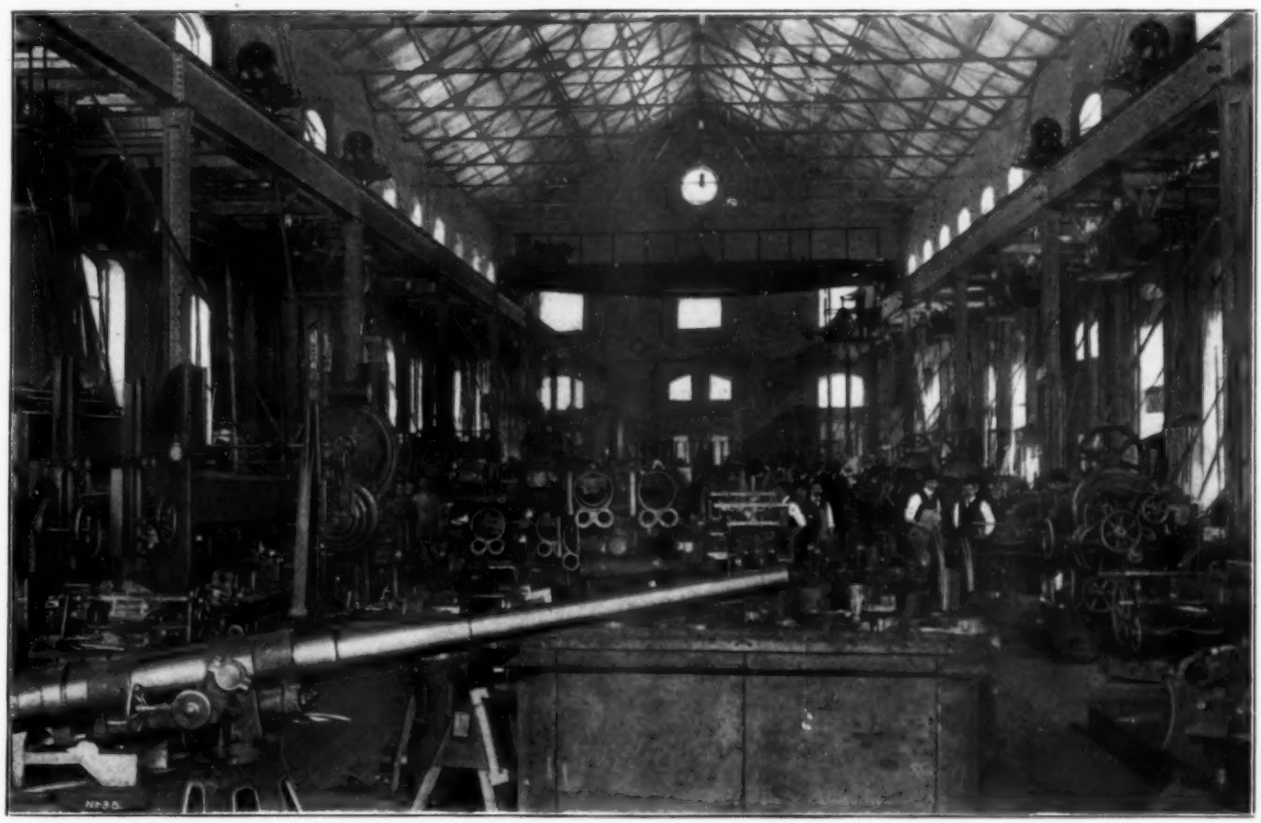


FIG. 66. MISCELLANEOUS SHOP, LOOKING EASTWARD

Sight Mounts—A Very Important Line of Work

The development of sights for the guns has been the object of a great amount of investigation, invention, and experiment, and the naval authorities now feel that they have something of great value in the present designs, a view which certainly seems to be supported by the fine showing which the gunners of the navy are making at target practice. The sight work is very interesting; it affords an opportunity for much ingenuity to be shown both in the design of the sights and in the planning of devices and arrangements for constructing the parts, some of which have been described in the AMERICAN MACHINIST. The accuracy demanded on this work is probably on the average higher than that in any other department of the gun factory. On the drawings, the degree of accuracy required on each finished part is indicated by a grade number, there being six grades of finish, with well-defined limits. On the working parts of sights, finish No. 1 is used, which means that the work must be within 0.0005 inch. The limit for finish No. 2 is 0.001 inch, which is used where there is no fit. No. 4 is plus or minus 0.025 inch. No. 5 means a rough forged finish and No. 6 a rough cast finish, permitting an outside variation of +0.15 inch and an inside of —0.15 inch. The male parts are made to dimensions, and the tolerance is allowed in the female parts. The latest practice in the navy requires that the steel parts be copper-plated, and accordingly, on the completed outfits, to the black of the iron and the yellow of the brass is now added the contrasting red of the copper. One of the important pieces of the sight mount was illustrated at page 732, Vol. 29, Part 2, in an article in which the general plan of the sights was touched upon. Our readers will also remember the descriptions of some devices used in this shop for graduating the scales of the sights.

General View of the Miscellaneous Shop

Fig. 66 is a general view looking eastward in the miscellaneous shop. The gun which shows so prominently in the foreground, looking as if it were trained and elevated ready for business, is a 3-inch 50-caliber navy gun. Behind this gun on the left is a 72-inch Bullard boring mill, and just beyond that is a Beaman & Smith open-side milling machine four feet

wide by eight-foot bed. Beyond the milling machine is a Bement, Miles & Co. slotter with a stroke of 24 inches and a table of 44 inches, and beyond that is a planer with a table 38 inches by 18 feet, and 46 inches between housings. Alongside of the slotter are a lot of slides for three-inch guns. On the right are some Bement-Miles horizontal boring, drilling and milling machines; the first three have tables 3x4½ feet, and the others are somewhat smaller. In the center of the shop (back of the muzzle of the mounted 3-inch gun in the front of the picture) they are setting sights on a 3-inch 50-caliber gun. In Fig. 67 some of the row of

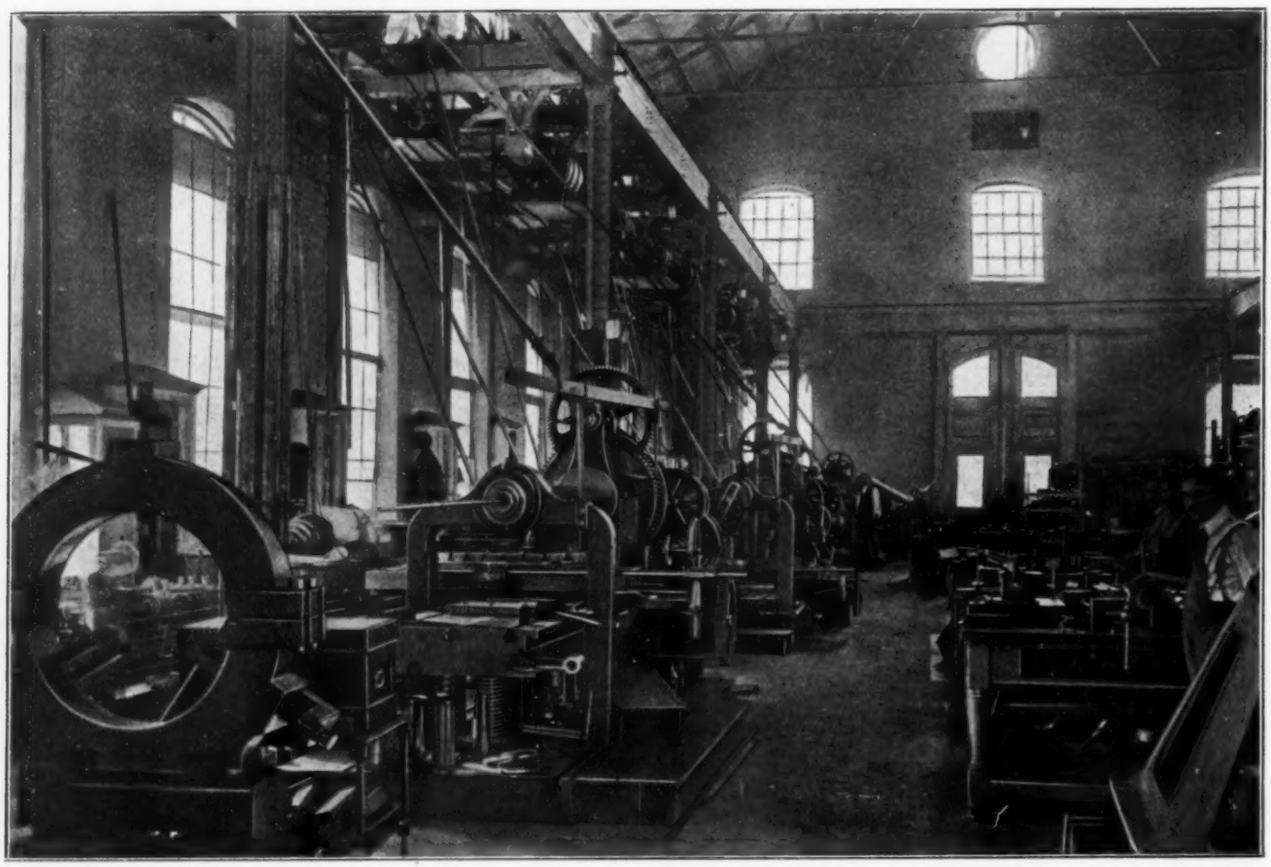


FIG. 67. MACHINING PARTS FOR THREE-INCH GUNS

horizontal boring, drilling and milling machines partly shown in Fig. 66 can be better seen. These machines are at work on parts for 3-inch 50-caliper guns.

Some Interesting Details

Among the numerous points of interest in this shop may be mentioned the following: on the part of the sight mount known as the azimuth crosshead there is a curved rack, all the teeth of which are cut at one operation on the milling machine by a formed cutter made in one piece. For 3-inch sights the rack has 14 teeth; for 3-pounders 21 teeth, and for 4-inch sights 18 teeth. Twenty-six azimuth plates are machined at once on the boring-machine table by setting them around to form the circumference of a circle. In a similar manner 12 elevating sight brackets for 4-inch guns are turned at once in the boring mill.

The Tool Shop

The building next north of the miscellaneous shop in the same row is the tool shop, which was built in 1901. It is a brick building of the same size as the two preceding and represents on a large scale the tool room of a machine shop. The whole building is occupied by a large and varied assortment of machine tools and 216 men engaged on making and repairing the tools, special devices, jigs and fixtures used in the other shops, including the construction and refitting of the wood reamers or packed bits for the gun lathes, and dies for drop forgings used in the forge shop. A large collection of the boring tools is located at the east end of the shop. These tools are made by taking a flat bar and mounting two cutters upon it, and piecing out with wood on each side of the flat bar in order to make a cylindrical form; their use was referred to in describing the construction of guns, in the fourth article. In the tool shop are also made battery boxes for firing guns, and the pressure gages previously mentioned (page 207) for taking the gas pressures in the guns. Like the other shops, the group system of electric driving is used, there being in the tool shop four 20-horse-power motors. Fig. 68 is an exterior view of this building and serves also to show the appearance of the other shops of the same size in this row. Fig. 69 is a general interior view in which it is quite evident that the employees know that they are having their pictures taken. This portion of the shop contains four Pratt & Whitney 14-inch tool lathes and three Bement, Miles & Co. slotters having strokes of 24 inches, 8 inches and 12 inches, and tables of 36 inches, 18 inches and 24 inches, respectively. Several packed bits are piled near the front of the picture. Fig. 70 is a near view of the Pratt & Whitney toolmakers' lathes, and in the background is a 16-inch Bement, Miles & Co. slotter. The machine at the extreme right in the foreground is one of two Brown & Sharpe No. 3 Grinders, and the lathe next the wall is a 14-inch Pratt & Whitney. Practically hidden in the corner are three shapers, and other machines. These machines are engaged upon making milling cutters, tools, jigs, etc. There are in the shop three Sellers tool grinders for grinding large tools for the gun shops.

At page 207 reference was made to the Pratt & Whitney measuring machine located in the office of the tool shop. This machine, unlike the one in the gun shop, is made without gearing in the head,

thereby eliminating this detriment to accuracy. The instrument is capable of measuring up to 36 inches in length. The screw has 50 threads to the inch, and the wheel has 400 small divisions, each one of which, therefore, indicates a longitudinal movement of

$$\frac{1}{50} \times \frac{1}{400} = \frac{1}{20{,}000} \text{ inch.}$$

The larger graduations and the figures on the circle indicate the number of ten-thousandths.

The Pay and Working Hours of Machinists in the Navy Yard

The men work 8 hours per day (from 8 a.m. to 12, and from 12:30 to 4:30 p.m.; the night shift from 4 p.m. to 12 midnight), 48 hours per week, and annually get 15 days' leave with pay; besides which, such men as serve in the District militia or in the naval reserve do not have their pay docked during their annual service. No piece work is employed; the men are paid on a time basis, being divided into classes, each of which has a definite rate of pay, there being a constant difference of 3 cents an hour between successive grades. The first class gets $3.36 a day, the second $3.12, the third $2.88, and the fourth $2.64. Then there are higher grades, such as machinist leading man, quarter-man machinist, master mechanic and foreman; the first of these gets $3.60 per day, and the second $4.16.

FIG. 68. TOOL SHOP

Apprentices

Apprentices are usually from 15 to 18 years old at the time of their entrance, and are paid $0.56 a day for the first nine months. They have to undergo examinations every six months to determine their

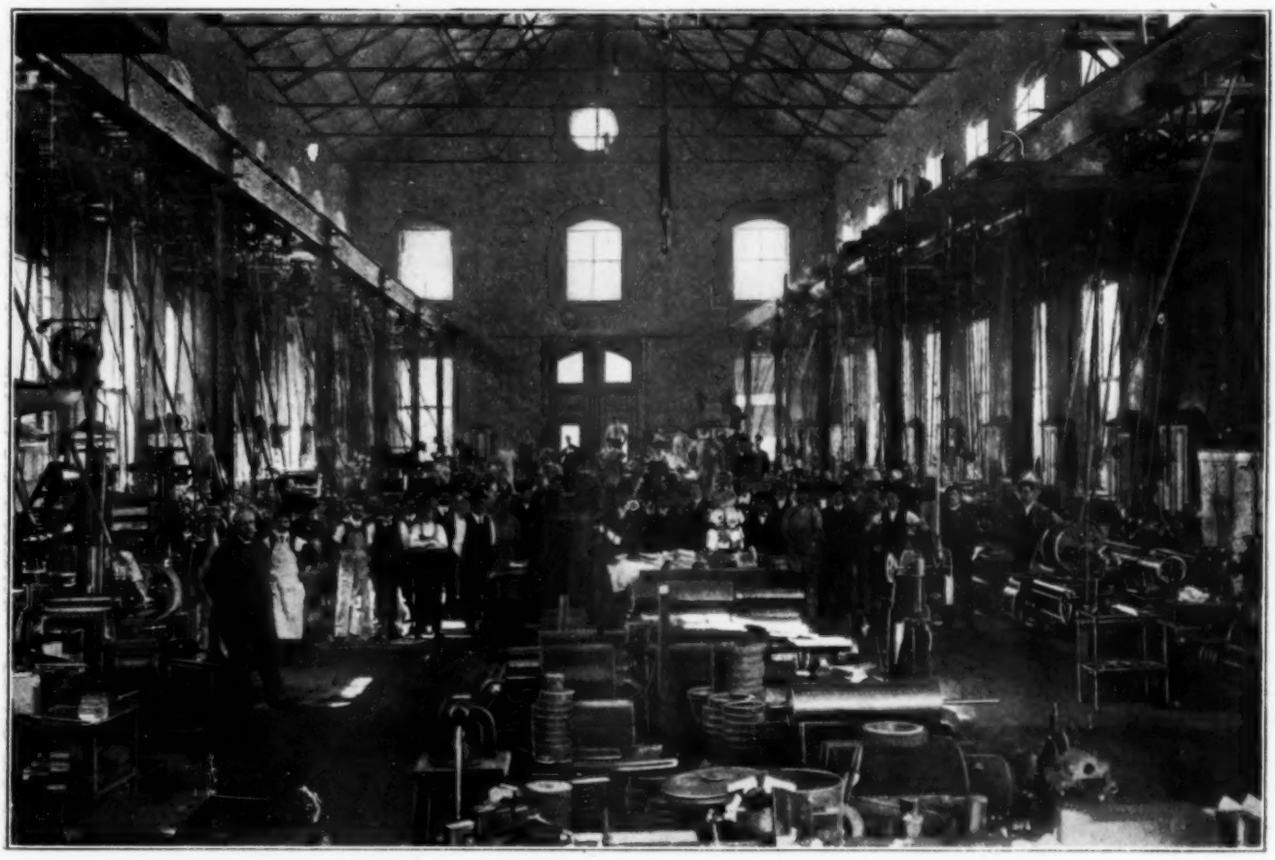


FIG. 69. MIDDLE OF TOOL SHOP

progress. During the second nine months, they are paid $0.80 a day, $1.20 the third nine months, and after that, for the remainder of their four years' term, they get $1.52 a day.

The Gunners' Workshop and the Gunners' Storehouse

North of the shops along Patterson avenue so far described are two smaller two-story brick buildings, equal to one another in size, namely 60x206 feet. One of these, which was built in 1901, and is shown in Fig. 71, is used as a shop for various purposes in connection with ordnance. On the first floor there is an electric traveling crane built by the Morgan Engineering Company, with a main hoist capacity of 22,400 pounds, and auxiliary hoist of 6720 pounds. On this floor are made, among other things, gas checks, which are placed in a gun in front of the breech block to prevent the gas from escaping at the breech; the pressure developed when the gun is fired flattens the pads out and squeezes them out sideways, so that the greater the pressure the tighter the joint. A great amount of experimenting has been done with the object of improving the gas checks, various mixtures having been used; the present pads are made of asbestos and tallow. In order to prepare the substance and press the pads into shape there are on this floor a 31-inch mortar and pestle, a steam oven, a screw press, and a 1000-ton hydraulic press.

FIG. 71. GUNNERS' WORK-SHOP

The painting of gun mounts, and of the ammunition boxes made in the pattern shop, is done here, the latter being painted different colors according to the kind of shell for which they are intended. Other work done in this building is that on rope of various kinds, and canvas and leather work, including the making of cartridge bags, etc. A portion of the second floor is partitioned off as a photographer's room.

The other building of this pair, the gunners' storehouse, has an electric crane the

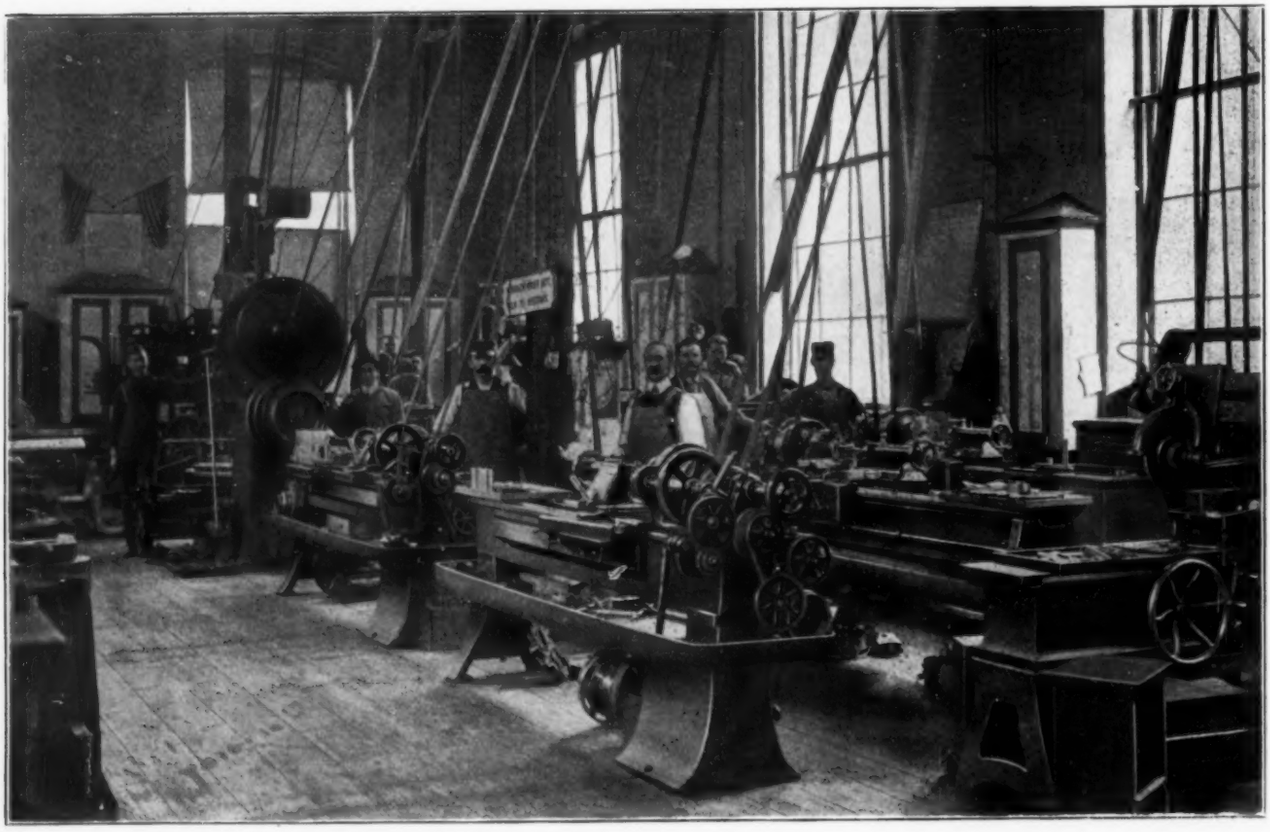


FIG. 70. TOOL SHOP

same size as that in its twin; in this building mounts and guns are crated for shipment.

The Seamen Gunners' Class

For many years it has been the practice to take certain enlisted men who possess the proper qualifications, and give them a course of instruction at the Washington navy yard, so as to qualify them for seamen gunners. These men in their sailor costumes may be noticed in all the shops, walking around in charge of officers or experienced men, who explain to them thoroughly the process of manufacture, and the construction, care and handling of the guns, mounts, torpedo tubes, fuses, primers, cartridge cases, etc. This course is found to be of great value in fitting the seamen to take care of the armaments when on board ship, and to make minor repairs when necessary. While at the navy yard these men are quartered in a large two-story frame building, which was built in 1904 in the northwest corner of the yard, on space which is shown blank on the map, Fig. 2, because of the latter not being sufficiently recent.

In 1900 there were 123 men in this class; in 1906 the number was 164. The course now takes 41 weeks, only 19 of which, however, are spent at the gun factory, 20 weeks being spent at the torpedo station, Newport, R. I., in theoretical and practical work with torpedoes, air compressors, naval defense mines and counter mines, explosives, electricity and diving; and two weeks are spent at the naval proving grounds.

The Foundry

The present foundry is an old brick building dating back to 1867, and of all departments in the yard its size and facilities are probably the most inadequate for present needs, so that it is probable a new one will soon be built. The main portion, in which is the molding floor, is 265 feet long by 65 feet 2 inches wide, and 38 feet 6 inches high at the eaves; on the north side of this is another part a trifle shorter and 36 feet in width; the aggregate area of the two is 26,734 square feet. The foundry contains three Whiting cupolas, Nos. 3½, 6 and 9, a steel-casting furnace, three brass furnaces, and two electric traveling cranes.

North of the foundry is a narrow two-story structure of about the same length, on the second floor of which patterns are stored. On the ground floor it has Newton and Wagner cold saws, wheels for grinding castings, space for storing molding sand, etc.

A curious product mentioned in a consular report from Paris is called calcium steel, although it contains no steel or iron in any form. It is a ceramic product formed by baking a paste made of finely pulverized feldspar, sand, and lime mixed in certain proportions. The product has remarkable qualities, being a porcelain or earthenware of great hardness and durability. It resists corrosion by acids, is a poor conductor of heat and electricity, and has a specific gravity of only 3.3. Although hard, the material is very tough, and can be machined like metals, being readily bored, cut, planed or polished. One of the uses for which it is expected to prove valuable is for pipes and conduits for water, gas, and chemicals.

Oxidation of Iron

The rusting of iron is accelerated by the presence of copper, and retarded by such metals as tin, lead, zinc, manganese, aluminum or magnesium; the phenomena are to be attributed to the hydroxide of the metal which dissolves in the water, for similar stimulating or paralyzing effects are produced on the iron by water which has been in contact with the metal. Arsenic and its compounds exercise a paralyzing effect on the rusting of iron, and when present in large quantities stop it altogether; in this case the dissolved iron hydroxide forms colloidal, ferrous, or ferric arsenite. Soluble salts such as the chlorides and sulphates of the alkali metals have a stimulating effect on the rusting of iron, probably due to their electrolytic dissociation, while among organic substances such compounds as sugar, phenol, or resorcinol stimulate the formation of rust; alcohol or methyl salicylate has a retarding effect, and acetic or salicylic acid dissolves the iron as rapidly as it is oxidized.—*The Electro-Chemist.*

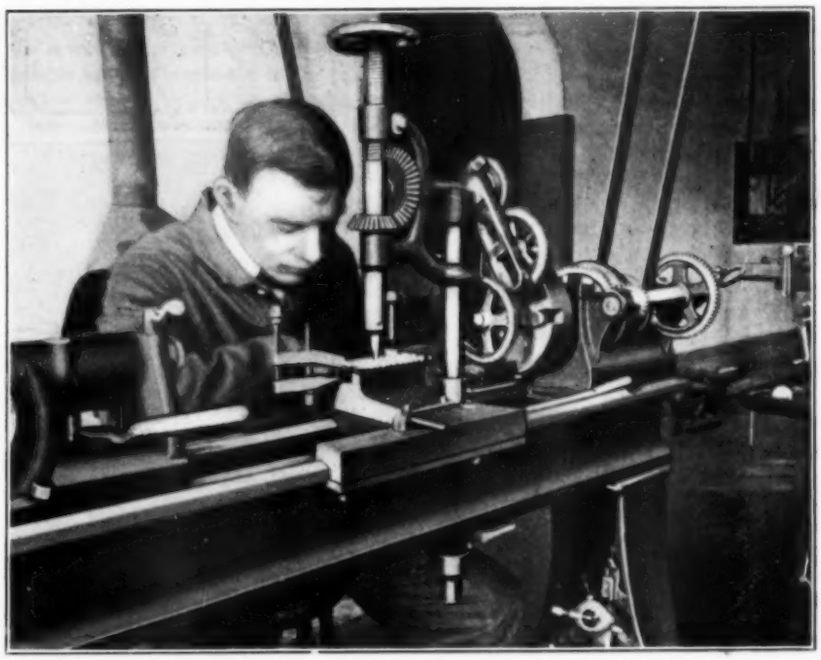
Doing Work Under Difficulties

By Carroll Ashley

Those who are used to having the necessary tools for doing difficult work do not appreciate their good fortune, until they strike a job where they have to produce the goods with nothing to work with.

I myself have thought that with a 26-inch upright drill press to take care of my sensitive drill work, surface grinding on the shaper, driving mandrels into work in a vise, having to trim down 3-inch steel to make a 1½-inch cutter, backing off cutters with an 8-inch file, etc., I had a pretty poorly equipped tool room.

But when I saw the lay-out my friend in the picture had, with which he was expected to make repairs and new parts for a set of automatic hook and eye machines,



VERTICAL MILLING ON THE LATHE

I was more contented with my lot. His complete equipment consists of a 10-inch screw-cutting lathe, a hand miller, an antiquated drill press, and a hand forge. It is obvious that he has had to improvise ways and means for getting out his work that would make interesting subjects for readers of the American Machinist. I have asked him to say something on these lines, but he says "some time I may."

He has told me of numerous small cutters made on the hand miller, which were 0.020 inch diameter. Though cutters this small would not bother a watch maker perhaps, my friend is not of that persuasion, but merely a close working tool and die maker.

Now he had quite a lot of work that required a vertical mill, so he made one by attaching the upper part of his drill

press to the lathe bed. While I was waiting for h'm to rig up for the picture, he told me it cost the company eight cents, outside of his time, to make this device.

He first puts a mandrel in the lathe chuck and fastens a gear thereon by means of a key and nut; then he clamps the column of the press rigidly on to the shears of the lathe; next the quadrant, on which is a driving gear and an idler, is removed from the lathe and is slipped on the horizontal shaft of the drill press; the idler is meshed in the gear in the lathe chuck and clamped fast. The device is now ready for business. The work is clamped to the tool block, and by operating the carriage and cross feed the work is moved in any direction desired. It is understood, of course, that the cutter is held in a chuck in the spindle, and the adjustment of the cutter vertically is by means of the hand wheel shown on the upper end of the spindle, just above the operator's head.

The picture shows the inventor of this device, John Imschweiler.

I wish to note my appreciation of the different points brought out in these columns by Mr. Markham, Mr. Hardy, Mac, and others who have answered my article on "Tempering Steel with Cyanide." I purposely made the terms of my answer to Common Sense a little ambiguous to draw an answer from some of the big fellows.

I must have conveyed the impression that my sole desire in the application of cyanide was to make the piece harder by its use. I only use it on Novo to protect the sharp corners from fusing, and on tool steel to prevent changing or distortion.

I cannot agree with Mac on "knowing my steel" because I have and use a quantity of both flat and round steel of a certain brand, and I have found there are different degrees of this steel and different results can be got from different bars all marked the same.

The eucalyptus of Australia has peculiar foliage. The leaves are vertical instead of horizontal, and offer little protection from rain.

A Built-up Blanking Die that will Keep Its Size

By Julius F. A. Vogt

Large blanking dies, solid and built-up, all have the same fault when ground off for sharpening, that they will not retain their size. This is a very serious matter when there is a limit to the size of the blank, and the punches as well as the dies are hardened. To overcome this difficulty I have built large blanking dies of different shapes, which will keep their size at all times, no matter how much is ground off the top. For the sake of simplicity the sketch herewith shows an oblong square, built-up blanking die 24x29½ inches, which was built under my supervision, and which was used for cutting six blanks at a time, that is, taking six sheets of No. 26 gage iron, one on top of another, and cutting them through at one stroke of the press.

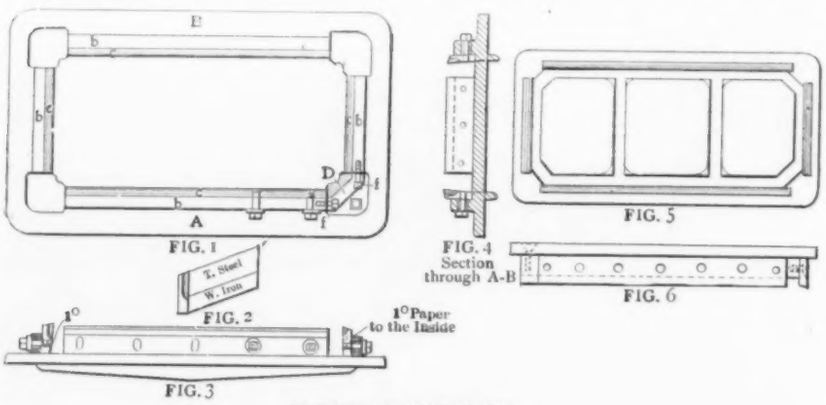


FIG. 1 FIG. 2 FIG. 3 FIG. 4 Section through A-B FIG. 5 FIG. 6

BUILT-UP BLANKING DIES

How They Were Made

Fig. 1 shows a plan of the die; Fig. 2 a knife or cutter; Fig. 3 a front view; Fig. 4 a section through *A B* of the die, and Fig. 5 the punch. The knives or cutters, Fig. 2, were made of a piece of 1x3-inch flat iron with a piece of good tool steel ⅜x1½ inches welded on to the inside top edge. The knives were planed, cut to length, hardened and ground. The die bed is a cast-iron frame and was planed off on the bottom first. It has four ribs *b b b b*, Fig. 1, cast on to the top of it to hold the cutters. The ribs are left open on the corners to permit the planing of the inside for the knife seats. These four ribs were planed out to the size of the die, plus the thickness of the knives, and were given a taper of 1½ degrees. The ends of the ribs were squared off for the corners *D*, Fig. 1. Oblong bolt holes for the knife bolts were cored into the ribs of the die bed. The die bed should be planed so that when the hardened knives are bolted on to it the die must be then of proper size. The next thing is to machine the four cast-iron corners *D*, of which only one is shown in the sketch Fig. 1; then the bolt holes *f f* are drilled in the corners, and the corresponding holes in the frame. Next, the four cornered knives are machined, fitted, and hardened, and bolted into place. These knives are held by the cast-iron corners *D*. There are no extra bolts to hold these corner knives in place.

Adjusting the Die

It will be seen in Figs. 3 and 4 that the knives stand with their bottom edges in the frame; also that the bolt holes in the frame are oblong, to allow the knives to be set up higher after they are ground off the top for sharpening. Now, if the punch fits too loosely, put so much under the knives to bring them up to the original hight. As the ribs *b b b b*, Fig. 1, are planed 1½ degrees taper and the knives are parallel, it is evident that by underlaying the knives on the bottom as much as there is ground off the top, the punch can always be made to fit. In other words, the taper on the die bed will keep the knives to fit the punch. The punch, Fig. 5, is made with a skeleton frame. The knives are made of the same material, and in the same manner as those of the die, with the exception that they are screwed on to the frame with countersunk screws. The punch frame is planed after the knives are hardened and ground, so that after the knives are put on to the frame the punch will fit the die. Then the corners are machined and fitted into their seat, as shown in Fig. 5. After that the corners are hardened and put into place.

Allow for Shearing Cut

Of course, the punch knives will have to be provided with shearing to suit the requirements. In this case the punch was sheared ⅜ inch lower in the center.

This die was made in January, 1904, and gave good satisfaction, cutting 7000 to 8000 blanks per day, which is a good output, considering the large sheets to be handled. After three years of service the die is now to be provided with new knives. I have used the same principle of construction on differently shaped dies, with very gratifying results.

According to the *Blacksmith and Wheelright* the wood of eucalyptus has not been extensively used by manufacturers in the United States because the supply has not been sufficient to establish a market. Blue gum, the most common species in California, has, however, competed with black locust for insulator pins, has given satisfactory service in chisel and hammer handles and has been used locally for wagon tongues, axles, shafts, spokes, hubs and felloes. It is hard, strong and tough.

Fifty thousand penny-in-the-slot meters are in use by the Manchester Corporation Gas Department; they sell 30 cubic feet of gas for a penny.

The Making of High-speed Steel Tools

How These Tools Should Be Heated for Forging and Tempering and the Apparatus Advisable To Use for the Purpose

BY O. M. BECKER

A recent study of machine and manufacturing shops throughout the country, in the course of which hundreds of plants west of New York were visited, convinces me that high-speed steel is not used to anything like the extent it should be. In very few shops was it found largely used, and in many scarcely at all. In some instances it was unknown. The demonstrated utility and all-around superiority of these steels in practically every line of metal-working, and in some lines of wood and other products, would lead to the supposition that they would be used to the largest possible extent. That they are not indicates a lack of familiarity with their merits, or unfortunate and misleading experiences with them. My judgment is that the latter cause is very common.

Prejudice and Inexperience

The fact is, the high-speed steel proposition is not attacked, in many shops, with the intelligence that is required for handling it successfully. The management having been persuaded in some way or other to buy some alloy steel for tools, the material is turned over to toolmakers quite likely unfamiliar with its properties and the methods of treating it. Prejudiced by their long experience with ordinary steels, the tool-dressers naturally fail to profit to the largest extent from the directions furnished; and even where these very brief and necessarily incomplete directions are followed as faithfully as possible, the inexperience of the tool-dresser with the new material makes his efforts more or less experimental. The results may or may not be satisfactory. If they are not, and the tools do not show a high efficiency, the experiment is soon dropped and a fine opportunity is passed up.

Buying Tools and Making Them

In the case of those who use relatively few tools the obvious thing would be to buy high-speed tools from experienced makers. If the specifications designate precisely the material upon which it is to work, and the machine in which it is to be used is at all adapted to it, the results should be satisfactory beyond any doubt. There will thus be no experimenting by tool-dressers who know nothing of the new steel, but good tools will invariably be on hand. The making of the simpler forms of lathe and planer tools is, however, so simple a matter that it can be undertaken in almost any shop having the usual tool-dressing facilities, provided the tool-smith is willing to learn the simple essentials in handling the new steels.

The large user of tools of course prefers, for the most part, to make most or all of his own tools, to save the profit in their making as well as because he frequently needs special tools not easily obtainable outside. Ordinary prudence would dictate the employment of somebody expert in working and tempering the high-speed steels, or at least getting an expert to teach the tool-dressers already employed to do the work properly.

What the Tool-smith Must Forget

In learning the peculiarities and properties of the new steels the smith must at the same time forget, for the time being at any rate, most of what he has been practising in working ordinary steels. His knowledge of colors, for instance, as indicating suitable temperatures, will not guide him at all in tempering high-speed steel. The blue or straw color, as the case might be, to which a tool-smith would draw a tool or carbon steel to get a certain temper, would have little effect upon these steels, which are susceptible only under very high temperatures. As a matter of fact, it is not safe to depend upon colors at all in tempering high-speed tools, as will be shown later.

First experiences in making high-speed tools ought obviously to be with the simplest kind, such as lathe, planer and shaper tools.

High-speed Steel for Tool-holders

Formerly it was a common practice to use high-speed lathe tools in connection with tool-holders, merely breaking off from the bar a piece of the desired size, grinding it to the required point, and inserting it in the holder. This is possible only when unannealed stock is used. This is still to be had of the makers; but its use is not good practice. The bar steel, while very hard, has not passed through a proper hardening process, having acquired its hardness while cooling under the stresses of the rolls and hammers. To insure an even temper and the absence of internal strains, it is necessary to anneal and then temper properly. For this reason, as well as because of the greater ease in separating the desired piece from the bar, the annealed stock should be used.

FIG. 1. AN UP-TO-DATE HARDENING ROOM

Advantages of the Annealed Stock

The annealed bar can be easily nicked and broken off, without resort to heating and cutting in the usual manner. If the tool is to be forged anyway, this, perhaps, does not matter much; though it is better to do what forging is necessary before cutting the piece from the bar. It is more a matter of convenience than any thing else.

An additional advantage in using annealed stock is that it may be readily machined without the necessity of drawing the temper. In making certain kinds

of tools this is of considerable importance. Again, the annealed stock is stronger, that is to say, tougher, in the neck or shank than the unannealed, and therefore tools are less liable to break at those points. The great power used to drive some of these tools makes it necessary to look after this matter.

Forging

For forging high-speed steel an ordinary forge fire will serve; though, indeed, better results may be expected if better apparatus is used. The principal thing is to secure the required heat, and to keep air currents away from the tool in heating. For small tools of the simpler sort good results are sometimes obtained from an ordinary open fire. The result is, however, much more likely to be satisfactory if a sort of hood is built up over the fire. This serves to prevent the radiation of heat and the circulation of air currents, and is a necessity in heating tools of any size. It also makes it easier to bring up the heat gradually, and to apply it uniformly on all sides of the tool, so that the heat penetrates uniformly. This is an important point.

Importance of Heating Uniformly

Unless the mass of steel to be wrought is uniformly hot throughout, it will work unevenly in forging, with the result that internal strains are set up which may ruin the tool when it is put at work, if not before. Though the heating is to proceed gradually, in the sense that it must be regular, it may go on quite rapidly. In fact it should be done as rapidly as may be without burning projecting edges or corners. Unless this is done the heat soaks up into the neck or shank, and when hardening takes place this important part of the tool loses some of its toughness.

The Right Heat

However, the fire must not be too hot, for in that case the outside is likely to be burned before the interior is thoroughly heated. In any event there is a likelihood that the tool-smith may be deceived into thinking the whole mass properly heated when in fact only the outside is hot enough for forging. If the interior has not reached at least a bright red heat, it is not ready for hammering. Of course, it is impossible to know the condition of the interior, except through its behavior under the hammer after removal from the fire, and it is therefore largely a matter of experience to determine the proper time during which a tool is to be heated. It is, perhaps, safe to say that if it has been properly protected as above advised, and brought up carefully in a moderate fire, the interior of a piece not more than an inch in section will be in proper condition for working when the outside has reached a bright yellow. No hammering should be done with the steel under a bright red color. Flaws and fine cracks are almost sure to result if it is done. The best results are obtained if it is worked at a canary yellow color.

Hardening Furnaces

Though a common forge fire, as already pointed out, when properly protected, will permit fairly satisfactory results in forging, a suitably designed muffle or other furnace is really necessary if any considerable amount of work is to be done; and it is all but essential to success in hardening and tempering. For the latter purpose a hollow fire is practically indispensable, and this is obtainable in most suitable form only in some specialized type of furnace designed for the purpose.

Part of the equipment of an up-to-date hardening room is shown in Fig. 1, which is a view taken in the Firth Sterling hardening plant in Chicago.

An Inexpensive Furnace

An inexpensive form of furnace answering excellently for this use is illustrated in Fig. 2. The fuel may be small lump coke, or anthracite, and the furnace will serve equally well for forge or hardening heats. The fuel feeds automatically, and is heated up sufficiently before entering the fire chamber, so as to make it possible to maintain a constant, even fire for any desired length of time, practically without attention. The temperature of the fire is, of course, regulated by the amount of air introduced, and is easily controlled by the cut-off in the pipe. Provision is, of course, to be made for shaking or poking down ashes should they clog the grate, which, however, is not likely to happen if the grate bars are properly spaced. As the gases from a coke fire are non-oxidizing, a tool is not injured from this cause, even though left in the fire a long time. The heat is so completely confined to the furnace that there is no waste of fuel or discomfort to the workman.

A furnace of this type serves equally well for forging and for hardening heats. For hardening purposes it is desirable to have some suitable arrangement for suspending the tools.

Oil Furnaces

Oil furnaces are not, in general, recommended for use with high-speed steel. The heating is not uniform enough, and there is a good deal of oxidation. On finished tools this is particularly objectionable. The oxidizing action can be in part obviated by the use of a muffle; but this again complicates matters and is itself an objectionable feature. I understand that there are certain oil furnaces which are not subject to the criticisms offered, though I have not seen them myself.

Gas Furnaces

Gas makes a good and very convenient fuel, if available. It permits uniform heating and absolute control. The objection is sometimes made that more or less oxidation takes place in the gas hardening furnace, and that it is therefore unsuited to closely sized tools. The oxidation complained of is mostly unnecessary, and generally takes place for the most part after withdrawing the tool from the fire and while it is exposed to the air. It is true that there is usually some unconsumed air present in the gas furnace, and that in consequence some oxidation will occur; but proper regulation of the air blast will reduce this trouble to a practically negligible minimum, except as to very particular pieces, as already indicated. A good gas furnace will be so designed that gas and air are admitted from several points, in proper mixture for combustion, and directed past rather than toward the center, so as to give the flame a sort of rotary movement. It ought to be designed so as to permit being entirely closed when in operation; and when used for hardening, so that the tools may be centrally suspended and kept from contact with each other or with the walls.

The Use of Muffles

In the case of very fine tools, such as must be very closely sized before hardening, they may be heated in a simple coke muffle. This method is also useful where the tool is of peculiar form and liable to distortion during the heating. A serious difficulty in the use of such a packing case is that of determining when the contents have been sufficiently heated. It is almost wholly a matter of judgment based on experience. About as much as can be said is that the muffle should remain in the furnace for three to four hours, according to the size, after the temperature has been raised to a white heat. Withdrawing wires, inserted for the purpose, may be resorted to, and may afford some guidance.

Heating for Hardening

The extent to which the heating is to be carried for hardening may vary within narrow limits, just short of the melting point. The steel will then be at a dazzling white, and just beginning to flux. Some brands reach this point somewhat short of the extreme white color. Where this is the case, care must be taken that sharp edges and angles of the tool are not melted down. This is especially to be guarded against in hardening taps, dies, and the like. As in forging, it is necessary to see that the heating proceeds uniformly and reaches through the entire mass of metal. Unless this is done strains are sure to be set up. Such strains, if set up in the forging, may be more or less completely relieved in the heating preparatory to hardening; but if they occur through inexpert hardening they are not later relieved, and sooner or later damage the tool, if indeed they do not ruin it

entirely. Too great care, therefore, cannot be exercised in this matter.

Milling cutters, reamers, drills, and similar tools are peculiarly susceptible to cracks resulting from internal strains. As these defects frequently do not show until long after the tools have been set to work, it is important that all possible precautions be taken and suitable appliances used in hardening them.

Heating Cutters, Dies, Drills and Reamers

Some tools, as milling cutters and dies for example, require heating entirely

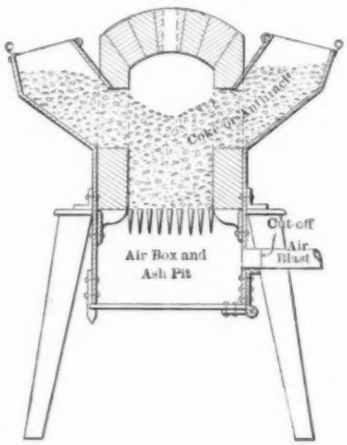


FIG. 2. AN INEXPENSIVE HARDENING FURNACE

through. Others, as lathe tools, should be heated at the point only, the neck of the tool being left annealed as much as possible. If the tool has been forged and allowed to harden afterward, it is as well to heat the whole tool and afterward anneal the shank or neck, so as to secure the greatest possible toughness at that point. In the case of drills and reamers made of unannealed stock this is rarely necessary, if the hardening heat is kept out of the shank. For this purpose the tools may be suspended through the top of the furnace, when the latter is so designed as to permit of it, with the part to be left annealed projecting outside. A cylindrical hardening furnace made by a New York concern is peculiarly adapted to this use. The device consists essentially of a cover provided with holes of appropriate size, through which the tools are lowered. The tools are secured by clamp tongs or handles with eyes and set screws at one end. The coke furnace shown in Fig. 2 could be fitted with a device serving the same purpose, with little trouble.

The Air Blast

Inasmuch as most of the high-speed steels harden by mere exposure to air, little apparatus is absolutely required in addition to the heating furnace; and some very good results have been obtained with none at all. The hardness of the steel depends considerably, however, on the rapidity of the cooling, therefore mere exposure to the air and slow cooling is not always satisfactory—for many purposes, indeed, it is very unsatisfactory. Most makers recommend the air blast for hardening. As this furnishes a continuous supply of cool air in rapid motion, the result is generally good. Since part of the latent heat in the air is extracted in the process of compression, compressed air is better for the purpose than that from a blower. The convenience and simplicity of this agent, where available, recommends it.

Disadvantages

Two disadvantages, however, should be mentioned, neither seriously impairing its usefulness, namely: the cost and the oxidation. The oxidation is negligible except in the case of the finer tools, in which case it may be objectionable. Though steel and oxygen combine readily at the high heat necessary in hardening these steels, yet the cooling takes place so rapidly that little, if any, damage generally results. As to the cost, that is another matter, one usually quite overlooked, particularly if air is used in large quantities. If much hardening is to be done, a less expensive agent should be used. Such a one is found in oil.

The Oil Bath

Fish oil or any other of the cheaper grades answers every purpose. Evaporation is very slight, and the expense of replenishing such a bath is very small indeed. For use in a shop making few tools, no apparatus other than a suitable tank to hold the oils is necessary. If, however, a good many tools are hardened, it is not only desirable, but almost necessary to keep the oil stirred up and properly cooled. In such a shop air and flowing water are generally available, and these offer about the simplest means for accomplishing this end. A suitable arrangement embodying several desirable features consists essentially, as shown in Fig. 3, of an outer tank containing water, within which is supported a double cylindrical oil tank, the inner cylinder opening into the large tank, so as to allow the water to circulate freely in both.

Provision for Water and Air

The water inlet reaches to the top of the inner cylinder, and the outlet is near the top of the outer, so that as long as the inlet cock is open, water is circulating around two sides of the oil holder. At the bottom of the latter is a circular pipe provided with a suitable number of holes, from which blower or compressed air bubbles up, keeping the oil well stirred. The water holder should be covered, or at any rate the inner cylinder should be, so as to prevent inadvertently plunging a tool into the wrong tank, and to avoid possible spattering of water from the inlet.

The bath should be near the heating furnace, so as to require but the smallest interval between the removal of the tool from the fire and its quenching in the oil; for, as already pointed out, the contact of the intensely hot steel with the air is likely to cause more or less oxidation.

Method of Dipping

The manner of immersion is important in certain cases. All long tools, such as drills and reamers for example, should be immersed vertically and rather gradually. This precaution avoids unnecessary internal strains resulting from uneven cooling. The immersion is to continue until the tool can be safely handled, and then it is laid in a dry place for further cooling. It is not safe to remove the tool before cooled to the point indicated; nor to plunge it beyond the point to which it has been properly heated, in the case of such as are heated for part of their length only. Cracks or checks frequently result if this caution is not observed. If several tools are immersed at the same time care must be taken that they do not touch each other nor the sides of the tank. The oil must be in free contact with every portion of the submerged tool, otherwise, again, there will be uneven cooling and consequently those undesirable strains and the inevitable cracks already pointed out.

Water Cooling Should Be Avoided

Water must under all circumstances be kept away from hot high-speed steel tools. The smallest quantity is likely to ruin utterly the tool with which it comes in

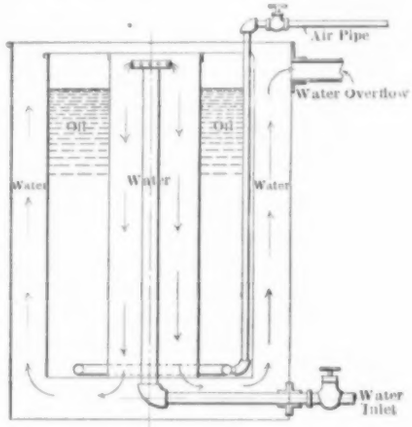


FIG. 3. OIL BATH

contact, and too great care cannot be taken in keeping moisture away. Water as a tempering agent is therefore out of the question. It is true that under some circumstances it is possible to make use of strong brine or soda water in the treatment of these tools; but the toolsmith with little experience with these steels cannot afford to do any experimenting with water cooling, something that even the best experts shy from.

Degree of Hardness Desired

For many purposes the tool, after quenching in oil and proper cooling, is

ready for use without further treatment other than grinding perhaps. For ordinary tools of simple design and sufficient cross section to make the brittleness concomitant with extreme hardness, the harder it is the better it will stand up. It is true, indeed, that under certain circumstances a tool soft enough to take a good Swiss file will do satisfactory work. But in general, softness is to be avoided except in those tools where it is necessary to protect the small or sharp cutting edges from crumbling. Such is the case in taps, threading dies, small milling cutters, and the like. Soft tools (relatively speaking, of course; for compared with carbon steel there is no such thing as a soft high-speed steel) are sure to "gum" quickly under anything like efficient speeds and heavy cutting, particularly in the case of those subject to a good deal of friction while at work —reamers and drills, for example. The safe rule is to make all tools as hard as possible, remembering, of course, the caution as to leaving necks, shanks, and similar parts in the annealed condition; and then "drawing" the temper of such as require it to the desired extent.

Tools That Require to Be Drawn

All small drills and taps, and threading dies of considerable size even, need to be "drawn," as also do most milling cutters —and in fact all tools whose cutting edge is in the form of a rather sharp angle. This process is, perhaps, the most difficult in the making of a high-speed tool, and requires more care and attention than any other. It is, of course, possible to get results, at times good results, with very simple apparatus—a fire and a nail keg have served. Such crude appliances, however, are not to be recommended where uniformity is desirable in tools of the same kind, or where tools for a variety of purposes are made.

Suggested Experiment

If it is desired to experiment with as little expense in the way of apparatus as possible, and to take the chances of failure, which is almost certain to result unless the tool-smith has had some experience with "drawing" the new steels, it may be done with least risk by taking, say, small lathe tools, such as are generally used with tool-holders, as a beginning. The tool is to be gradually heated until it reaches a dark straw color, and then cooled in the air blast or oil bath as when hardening. If a greater degree of softness is required, this may be had by allowing the tool to cool in air; or if still greater, by raising the temperature till it reaches a greenish tinge, and then cooling slowly. Sometimes better results are obtained by heating first to a greenish tinge and cooling, and then re-heating to a barely perceptible red—that is, a red just perceptible in the dark. The nail keg already mentioned may serve to give the required darkness.

Color not a Safe Guide

The color scheme as here outlined is obviously very general and necessarily rather indefinite. For this reason color is not a safe guide in the treatment of high-speed steel. The variation in color that will cause an important difference in the temper is often so slight as to be scarcely perceptible to the most experienced eye, even. The only way to insure uniformity and accurate work is to use suitable appliances. About all that is actually required for this purpose is a bath capable of being heated to and maintained at temperatures up to about 350 degrees Centigrade, which is the equivalent of a little more than 660 degrees Fahrenheit. A good high heat thermometer is a part of the apparatus.

A Tempering Furnace

A good form of tempering furnace, using an oil bath, consists of a suitable tank, supported or suspended within which is a perforated pan for holding the tools to be drawn. A thermometer is suspended in

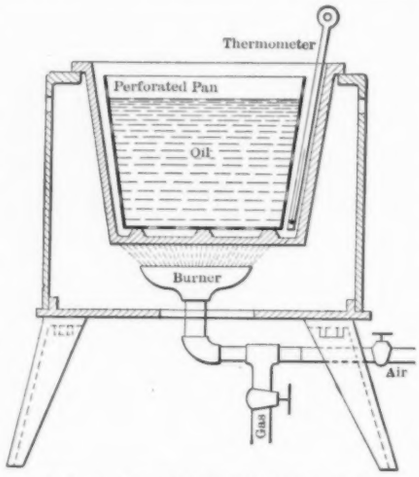


FIG. 4. OIL TEMPERING APPARATUS

the bath. Gas is perhaps the most convenient fuel because of the ease with which the temperature can be regulated; any other convenient fuel may be adapted to the purpose by properly designing the heater. A convenient form of furnace is illustrated in Fig. 4.

In using the oil bath for drawing the temper of high-speed steel tools, unless there should be some special requirements or conditions, it is safe to draw milling cutters, drills, thread cutters, and the like to about 250 to 260 degrees Centigrade, which is approximately 480 to 500 degrees Fahrenheit. Small taps and threading dies, drills of small diameter, and similar tools requiring unusual toughness because of the small cross section or sharp cutting edge, must usually be drawn considerably higher, say to about 350 degrees Centigrade or 660 Fahrenheit.

Alley Baths

There is another method of accomplishing a result that is reasonably certain, and which requires no apparatus except a melting pan, any sort of fire giving heat, and a suitable quantity of alloy of the proper mixture. If different degrees of heat are required, as will be the case if a variety of tools are to be made, several variations of the alloy will be required. Lead and tin, when mixed in varying proportions, have different melting temperatures. An alloy which melts at 250 Centigrade, for example, contains 13 parts lead to 4 parts tin; at 260 Centigrade, 17 to 2; while the mixture melting at 325 Centigrade contains 100 parts lead to 1 of tin.

Heating the Bath

In using these alloys for tempering, the heat should be just sufficient to melt them, and no more. For this reason gas or oil is preferable for fuel. If the metal does not "set" around the tool when first immersed, the temperature is higher than the melting point. A few degrees of difference of course does not particularly matter. In fact a slightly higher temperature than that of the melting point is necessary, in order to keep the metal fluid. The tool is slowly immersed in the bath and allowed to remain until heated through. It may then be quenched or cooled in air, as when using the oil bath. The simplicity of this method recommends it. Its obvious disadvantage, however, is the impossibility of varying accurately the temperature of the bath without a considerable variety of alloys in stock.

Records Should be Kept

It ought to be scarcely necessary to say that a proper system of records showing the essential facts in the tempering of tools of this kind is of great value. The record ought to show not only such data as relate to the making of the tool, but its efficiency in the shop, so as to afford a basis for varying the treatment in case the tool should turn out poorly.

The broadening field of engineering education is well illustrated by the installation of courses of study in railway engineering and its administration by the University of Illinois. Four courses are now offered, covering railway civil engineering, electrical engineering, mechanical engineering and administration. The university has already a very substantial equipment for work in these fields, this equipment comprising railway and electric-railway test cars, and the addition of a transportation laboratory is under contemplation.

Prof. J. D. Hoffman, of Purdue University, Lafayette, Ind., is engaged in revising his catalog file and in bringing it up to date. He would be glad to receive the catalogs of manufacturers of all classes of machinery and power-plant equipment, which will be properly filed for the use of the students.

The Kerr Steam Turbine

By C. V. Kerr

Turbines have been classified as impulse, reaction, velocity and pressure turbines, depending on the manner in which the energy of the steam is supposed to be used. To those who are familiar with water wheels it will be more easily understood to say that the Kerr steam turbine is built on the principle of the Pelton water wheel. It is a nozzle and bucket turbine of the purely impulse type, as compared with the guide and vane turbine of the reaction type. The most widely known of steam turbines at present are built on the principle of the water-turbine wheel. The Pelton or double-cup form of bucket gives a nearly complete reversal of the jet of steam. By compounding or dividing the turbine into several stages and the range of steam pressure into an equal number of drops, the

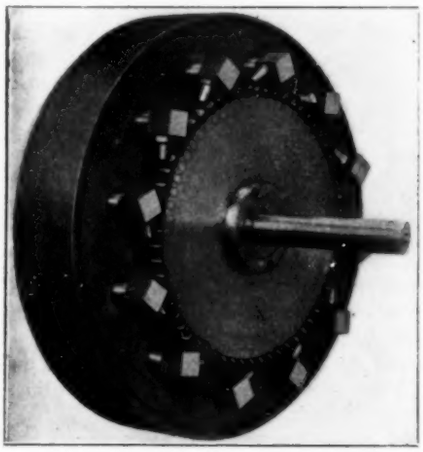


FIG. 1. TURBINE DISK MOUNTED ON SHAFT

speed of rotation is reduced so that gears may be avoided and direct coupling to driven machines secured. The complete reversal of the jet of steam enables the minimum number of stages to be used.

The Pelton type of water wheel has been chiefly used for high heads of water ranging from 50 feet to 200 feet. It is, perhaps, under such conditions, the most efficient of all water wheels. With high steam pressure and superheat it may be expected to show similar qualities as a steam turbine. In the old water turbine the highest efficiency was reached with low or medium heads of water for the reason that the lower the head of water and the larger the volume used the smaller the proportion of leakage through the unavoidable clearance spaces in the wheel. Hence, we find the water-turbine type of steam turbine calling for high vacuum and showing its best efficiency under such conditions. The large volume of steam in vacuum makes the leakage losses through the clearance spaces smaller in proportion. On the other hand the Pelton type of steam turbine is independent of leakage losses through clearance spaces and is consequently peculiarly adapted to the use of high steam pressure and high superheat.

The throttling type of governor is used, first, on account of its simplicity; second, the wire-drawing at light loads tends to superheat the steam and thus reduces the windage losses; third, by reducing the steam pressure within the turbine the internal resistance or windage, which is the chief source of friction losses in the steam turbine, is reduced and made nearly proportional to the load. For this and other reasons the brake horse-power developed by the turbine is found to be proportional to the steam pressure. The highest potential efficiency or the largest proportion of available heat converted into work has been found for the lighter loads. The result is a flat steam-consumption curve.

In Fig. 1 is shown one of the turbine disks mounted on the shaft in position within the circle of nozzles leading the steam from one stage to another through the castings, called on this turbine diaphragms. The shaft is made from high-grade open-hearth steel which is turned nearly to size, key-seated, drilled and fitted, then annealed under steam temperatures to remove all internal strains likely to be effected by steam heat within the turbine. Afterward the finishing cut is taken on the shaft to secure true running. The disk is screwed on to the split hub against a shoulder, thus clamping the hub in place on the shaft. A lock-ring follows the disk. The double-cup buckets are drop-forged from mild steel and secured to the disk by lightly riveting in dovetail slots. After the disk is otherwise complete it is balanced on a mandrel rolling on knife edges, which permits almost exact static balance to be secured. As the mass of metal is in a plane at right angles to the axis of rotation, the static balance obtained secures also a running balance. The slight errors unavoidably left in balancing tend to neutralize each other when several disks are mounted at random on the same shaft.

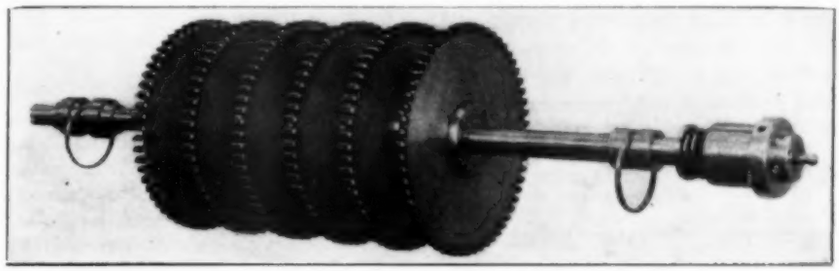


FIG. 2. SHOWING A NUMBER OF DISKS ON SHAFT

The nozzle bodies are made from square cold-rolled steel and secured in place in the diaphragm by expanding and beading like boiler tubes. The nozzle tips are accurately formed from hexagon cold-rolled steel and screwed firmly into the nozzle body. This construction permits the possible replacing of the nozzle tips, if needed, on account of wear or of changing the size of the nozzles to secure greater or less power. The diaphragms are made from cast iron with circular rim and arched center to withstand the steam pressure to the best advantage. Each diaphragm has a tongue on one edge and a groove on the other. When fitted together, fiber packing treated with graphite and oil is laid in the groove, thus making an elastic packing backed by a metal-to-metal outer joint. Experience has shown this joint to be easily made, easily packed and always steam tight.

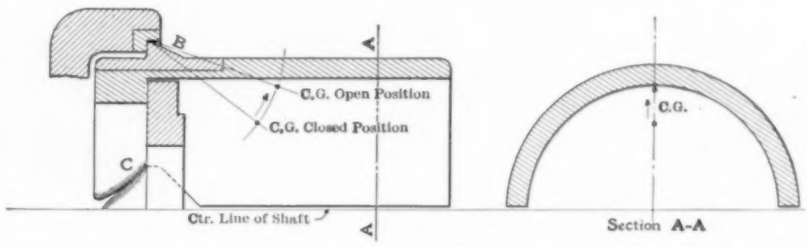


FIG. 3. ARRANGEMENT AND CONSTRUCTION OF GOVERNOR WEIGHTS

The mounting of a number of disks on the shaft is shown typically in Fig. 2. At the right-hand end is shown the governor mounted on the end of the shaft and one of the ring-oiled bearing brasses. At the left is shown the other ring-oiled bearing brass, together with the locating collar on either side of the brass. There is practically no end thrust in the turbine, and theoretically none. The locating collars are used for securing and maintaining an exact alinement of the disks with the nozzles.

Fig. 3 is a diagram showing the typical arrangement and construction of the governor weights shown assembled in Fig. 2. The weight is turned from solid steel, then split, resulting in weights of uniform texture, of semi-annular form, of good running qualities with the center of gravity near to the center of the shaft. The weights are supported at three points. The hardened-steel knife edge at *B* is straight and of sufficient width for the

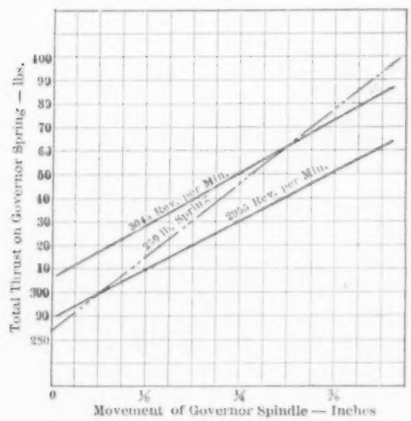


FIG. 4. TYPICAL STRESS DIAGRAM FOR GOVERNOR

stresses involved. At 90 per cent. on either side is a rolling contact at *C*. The curve is such that the bearing between the weight and the cam collar is always on the line of centers. Pure rolling contact is thus secured and the weight, without being fastened in position, is firmly driven by its triangular support. The outward movement of the weights compresses the spring and operates through lever connections the balanced piston valve controlling the flow of steam. The movement of the center of gravity is shown in the figure.

A typical stress diagram for the governor is shown in Fig. 4, in which the governor is designed for 3 per cent. total range of speed. In this case the centrifugal moments are reduced to the thrust on the governor spring. The result is a uniform increase in thrust with the movement of the governor spindle and steam valve. Proportions of weight may be easily found which will make these lines concave upward or convex upward, as desired. This permits the greatest stability of the governor to be secured for either light load or heavy load. In the diagram shown, equal stability at all points is given by the straight lines. The power of the governor or its ability to move the valve at any position is given by the vertical distance between the lines. Within reasonable limits this may be varied to suit the requirements. This construction secures a governor that is quick and stable, requiring no lubrication of the weights at the point of support.

In Fig. 5 are shown the working parts of the governor. The knife-edge blocks are here shown set in the rim of the cup. The spring is of the ordinary compression type with square ends seated on steel collars. The right-hand collar is movable and made long with a loose fit on the shaft to prevent binding. Motion is transmitted to the governor spindle by a transverse pin lying between the movable spring sleeve and the cam collar. This pin is free to take any circular position and rocks freely in the spindle, thus forming a universal joint.

The steam turbine is especially adapted to direct driving of high-speed machines. It is not like a patent medicine, good for anything and everything. The steam engine is a monument to the engineering profession of painstaking design and superior construction. It has qualities and applications which will secure for it, doubtless, continued use, no matter how widely useful the steam turbine may prove to be. A curious prediction was made at the time the locomotive was introduced into England, in effect that the horse would gradually go out of use. The advent of the incandescent lamp was heralded as a supplanter of the gas jet. Gas makers now tell us their industry is in its infancy. The automobile is now making its attack on the horse and carriage. In view of history which will survive? With the steam turbine and steam engine it should be a question of "live and let live," each seeking that which it can do best.

Among the high-speed machines which the steam turbine is especially adapted to driving are generators of electric current, pressure blowers and centrifugal pumps. In Fig. 6 is shown an 18-inch six-stage Kerr steam turbine coupled to a 30-kilowatt Burke generator delivering current at 125 volts and running at 3000 revolutions per minute. The floor space is somewhat less than 3x7 feet. The unit runs with very little noise, vibration or sparking. Between the turbine and generator is shown one of the ring-oiling bracket bearings used on this type of steam turbine. The bearing case is bolted to the exhaust-end casting of the turbine. On account of the heat transmitted to the bearing by the cast-iron support, and also by the steel shaft, a mineral cylinder-oil is used in the bearing case. This permits running the bearing at any temperature likely to arise without resorting to water-cooling or other devices. The body of the turbine is made up of steam and exhaust-end castings and diaphragms which are held together by through bolts. The body of the turbine is lagged to prevent radiation and covered with a sheet-steel jacket. Leakage of steam around the shaft at the steam end of the turbine is prevented by combining metallic and fibrous packing. From the spaces between, the steam leaking through the metallic packing is piped back to a lower stage of the turbine. At the exhaust end on non-condensing work, leakage of steam is prevented by simple fibrous packing. For condensing work an inner metallic packing is also used and the space between may be filled with water to secure a high vacuum.

The lubrication of the turbine is confined to the two-ring oiling main bearings and to the governor pivot block which is provided with a reservoir of oil. There are no internal rubbing parts and lubrication is not required. The exhaust steam is, therefore, free from oil of any kind and may be used for any purpose for which clean low-pressure steam is useful. The arrangement of turbine and generator permits either machine to be removed without disturbing the other.

The result of the construction of this type of turbine and the throttling system of governing is very well shown in the following comparative tests of steam turbines given by Foster in his book on "Steam Turbines," page 162 (the last line, relating to the Kerr steam turbine, is added):

FIG. 5. GOVERNOR PARTS FOR KERR STEAM TURBINE

Load per cent.	100	75	50	25
	Steam efficiency per cent.			
Zelly, 350 kw	100	80.3	58.8	36.3
Rateau, 1000 kw	100	78.0	55.6	33.7
Rateau, 500 kw	100	77.2	55.0	32.0
(U.S.A.)Westinghouse, 1250 kw	100	78.5	57.3	36.0
(U.S.A.)Westinghouse, 400 kw.	100	78.5	57.0	....
C. A. Parsons, 1500 kw	100	78.0	56.0	33.4
C. A. Parsons, 50 kw	100	78.0	56.0	33.7
Brown-Boveri, 300 kw	100	77.6	56.0	33.3
Curtis, 2000 kw.	100	77.2	54.2	31.4
Curtis, 600 kw	100	76.5	52.4	28.8
Curtis, 500 kw	100	76.2	51.7	28.1
De Laval, 200 kw	100	76.2	52.3	29.0
De Laval, 20 kw	100	82.0	68.0	52.0
Kerr, 30 kw	100	76.3	53.3	29.6

The accompanying table shows results of tests made on the turbines best known at the present time. The Zoelly, Rateau, C. A. Parsons and the Brown-Boveri are turbines of European make, while the others are American. The loads are stated as percentages of the most efficient load. The nearer the steam consumption approaches the per cent. of load the better the performance. Thus at 50 per cent. load the steam economy should be as near to 50 as possible.

The 200-kilowatt De Laval turbine was governed by varying the number of active nozzles, which would not be done in ordinary service. The 20-kilowatt De Laval turbine was throttle-governed in the usual way. The 50-kilowatt Kerr turbine was throttle-governed at all loads. These are results from the first condensing turbine of this type tested which was designed as a compromise to run either condensing or non-condensing.

An application of the steam turbine which is doubtless destined to be widely useful is the driving of centrifugal pumps for handling circulating water for condensing plants, for boiler feeding and for water-works service. The speed best adapted to the turbine makes a modification of the pump design necessary for best results from the combined unit. The development of the turbine form of centrifugal pump in late years for high-pressure work makes the application of the steam turbine easy. The pump shown in Fig. 7 was designed to deliver 200 gallons of water per minute against a head of about 360 feet. This corresponds to a pressure of something over 150 pounds, and the pump would supply at this pressure a boiler plant of about 3000 horse-power. Such units are mounted, as shown, on a cast-iron base, the pads of which are accurately surfaced. Correct alinement is thus secured and afterward maintained by dowel pins. The illustration shows an experimental unit designed for the engineering laboratory of the Armour Institute, Chicago. It is made up of an 18-inch Kerr steam turbine developing about sixty horse-power on condensing work, coupled to a Worthington three-stage turbine pump. The base is arranged so that by removing the pump and setting in place the outboard bearing pedestals, a brake-testing outfit is secured. The use of dowel pins in the setting of the pump and pedestals secures convenient handling and maintains an accurate alinement of the parts.

The third application to which the steam turbine is particularly well adapted is that of driving pressure blowers for supplying blast to forges, cupolas and gas generators. In Fig. 8, is shown a blower unit made up of a 12-inch Kerr steam turbine coupled to a No. 8 Buffalo blower used for supplying blast to a 36-inch cupola. The relation between the steam pressure and blast pressure is given by the straight line in Fig. 10. The corresponding relation between blast pressure and speed is shown by the curved line which is in form nearly a parabola. In ordinary service in this case a blast pressure of 7 to 9 ounces, or 12 to 16 inches water pressure, is used. The steam turbine was given sufficient power to provide for a margin over any blast pressure likely to be required.

By connecting a steam gage to the valve case below the governor valve, as

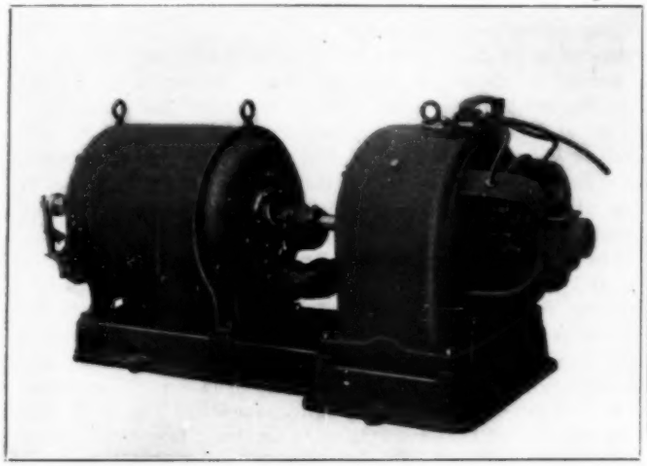


FIG. 6. KERR TURBINE COUPLED TO BURKE GENERATOR

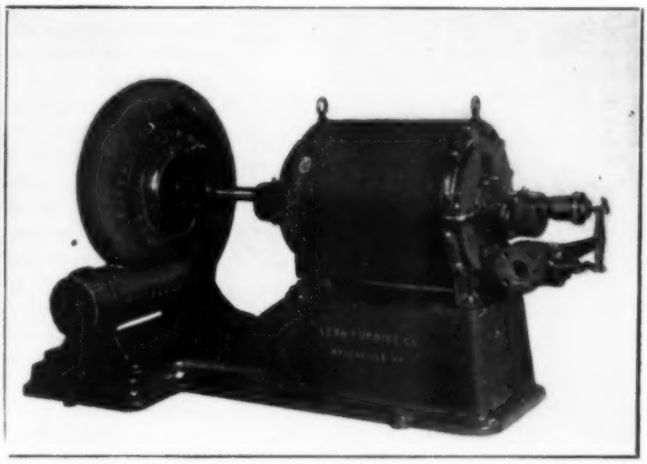


FIG. 8. KERR TURBINE AND BUFFALO BLOWER

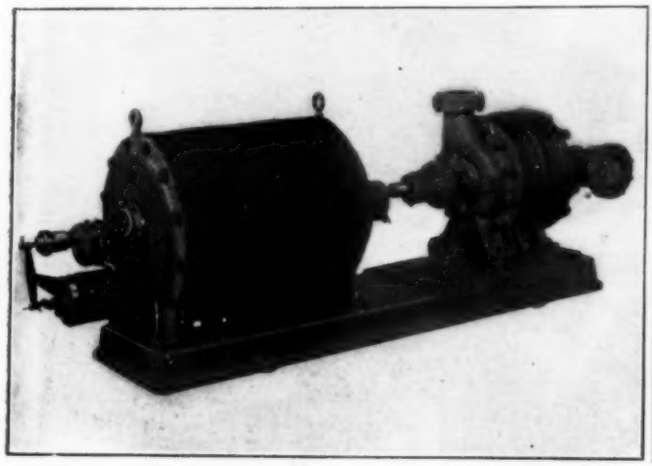


FIG. 7. TURBINE FORM OF CENTRIFUGAL PUMP

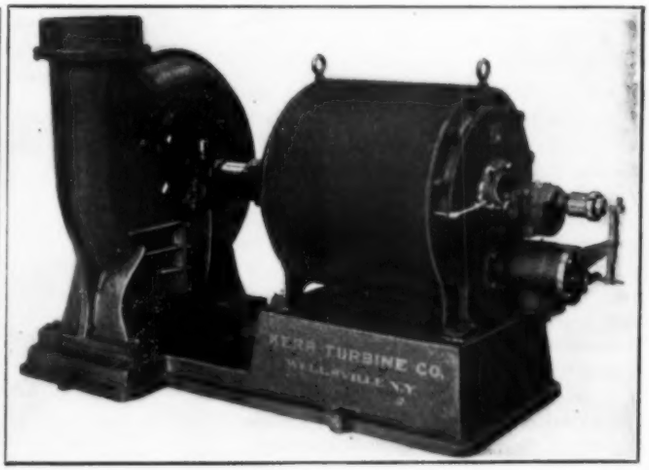


FIG. 9. KERR TURBINE AND STURTEVANT EXTRA HEAVY GAS BLOWER

shown in Fig. 11, the turbine may be run on the throttle for any blast pressure desired below the maximum or limiting pressure for which the governor is set. For instance, if 12-inch water pressure, or about 7 ounces, is desired on the cupola, a pressure of about 42 pounds gage would give the desired pressure at a speed of something over 1600 revolutions per minute. The high

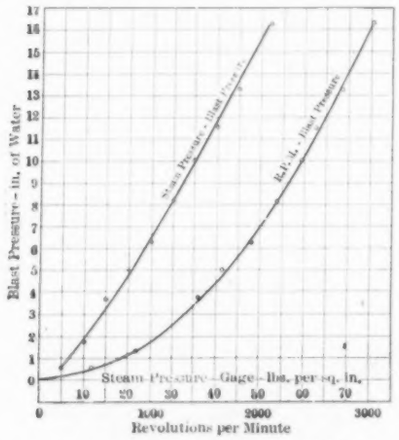


FIG. 10. SHOWING RELATION BETWEEN STEAM AND BLAST PRESSURES

pressure of 16 inches of water, or 9-ounce pressure, would be given by 52 pounds gage pressure at a speed of 2100 revolutions per minute. The cupola tender has thus the advantage of knowing the pressure of steam on his turbine, the speed in revolutions per minute and the blast pressure on his cupola, all indicated by the pressure of steam below the governor valve referred to the calibration diagram of Fig. 10. The annoyance and unreliability of the ordinary water gage is thus avoided. Here we find the advantage of the turbine over the steam engine for similar service of entirely avoiding the use of belts by this direct-coupled driving of the blower. For similar service the steam turbine will give better economy than the steam engine, together with the greater reliability obtained by avoiding the breaking and slipping of belts. The minor advantages of greater convenience in operation, of smaller space, clean exhaust and the ring-oiling bearings on both turbine and blower may be added to set forth the ideal unit for such purposes.

The water-gas process of making illuminating gas is chiefly used in this country. The process in brief consists in supplying air to a bed of fuel in a large retort or gas generator until a high temperature is obtained. Then steam is admitted which decomposes in the contact with red-hot carbon and water gas is obtained. This is afterward carbureted and becomes illuminating gas. As the decomposition of the water by the hot carbon absorbs the heat of the fuel bed the temperature is reduced in a few minutes to a point below which it is not practicable to continue the blast of steam. The air-blast is turned on and in a few minutes the fuel bed is again brought to the proper heat. This alternates at intervals of a few minutes day in and day out. For this work the turbine-driven blower, as shown by Fig. 9, has special advantages. The steam turbine is not affected by water entrained or carried over by the live steam, except by slowing down in case of an unusual amount. Under like conditions a steam engine would be in danger of knocking out a cylinder-head, or causing other damage.

The unit shown in Fig. 9 is made up of an 18-inch Kerr steam turbine, coupled to a No. 6 Sturtevant extra heavy gas blower capable of delivering air for such purposes at pressures depending on the speed, from 10 to 14 ounces or 18 to 24 inches water pressure. The usual pressure is about 12 ounces or 21 inches of water, given by a speed of about 2800 revolutions per minute. For this gas-works service the ability of the turbine to take full steam pressure and start quickly is very useful. The unit in question has been got up to full speed from standing start by admitting full steam pressure in from five to six seconds. In emergency the turbine can be started with full steam pressure admitted to the cold turbine without danger of distress or accident. The sectional construction of the turbine and the absence of small running clearance avoid almost entirely trouble due to heat expansion.—*Power.*

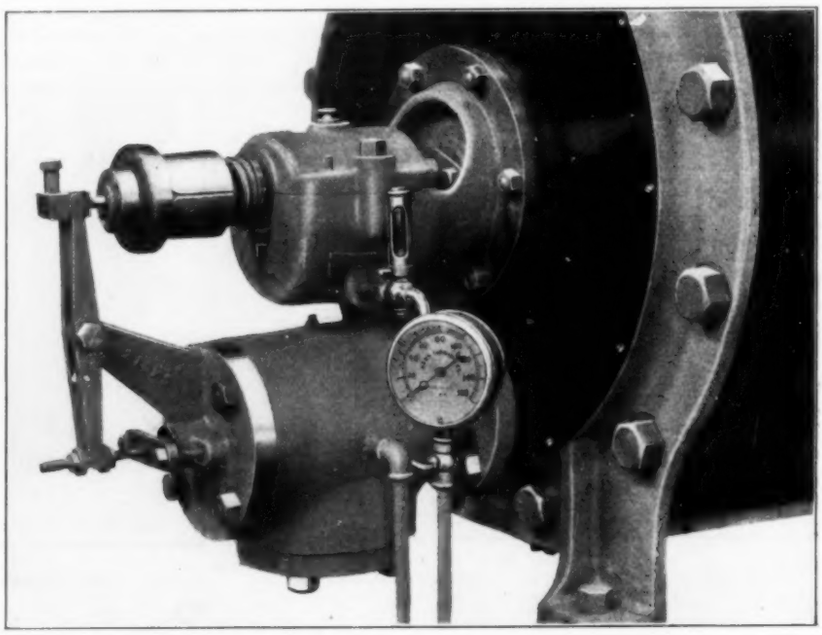


FIG. 11. GOVERNOR AND STEAM-END CONNECTIONS ON KERR TURBINE

A Staten Island editor got his paper out in spite of a seriously broken down electric motor by placing his 35-horsepower automobile alongside the building and making connection from the engine to the press through a hole in the wall.

Machining Steel Gear Blanks for Automobiles

By "Auto England"

The spur-gear blank shown in Figs. 1 and 2, is made from a drop forging for the change-speed gear box of a well known automobile, and is 5.883 inches outside diameter. The method here shown of machining them is the quickest we have yet devised, and may prove of interest to some of the readers of the American Machinist. They are all made true to gage, on a Warner & Swasey capstan lathe, in 45 minutes each—not a bad performance.

We first grip the blanks over the top in a four-jaw chuck, leaving a clear half width of the rim free of the chuck jaws to be turned over the top. I might add that we had previously tried gripping them on the inside of the rim, so as to allow us to turn completely over the top, but owing to the taper on the dies for stamping the blanks we could not hold them tight enough to stand the broad facing cutters operating on them. They are first bored out to 2¼ inches diameter, a roughing and a finishing cutter being necessary for this operation. The rough forming cutter, shown in Fig. 3, is then brought up to the front face of the blank, and the latter is roughed out. The capstan is then revolved and brought to the fourth tool, shown at Fig. 4, which finishes the front face of the blank completely. The countersunk holes marked *A*, in Figs. 3 and 4, are to receive the set-screw points for gripping them in the holder, shown in Fig. 5. The end marked *x* is turned to fit in the capstan, while the front pilot end *E* is hardened and ground

and driven into *x*, as shown by the dotted lines. This is done to cheapen its manufacture considerably, as the slot for holding the cutter, across the end of *x*, is gashed out in a milling machine, with a convex cutter of the proper width; whereas, if *x* were made solid with *E*, milling the slot for the cutter would be an expensive operation. The slot *C* can be slot-drilled in *E*, in a comparatively short time, the two pointed set-screws *D* grip the cutter firmly in the slot.

The next operation is to turn over the top of the blank as far as the chuck jaws will allow, a roughing and a finishing cutter held in an offset tool bar being used for this operation.

Finishing in Another Lathe

The blank is taken to another lathe to be finished in the chuck shown in Figs. 6 and 7. This chuck is mounted on a plain face plate, which is recessed to receive the spigot marked *K*, in Fig. 7. This locates it dead central. Three ½-inch set-screws secure it in position, by passing through the face plate, and screwing into the three holes marked *J*. The body of the chuck *F* is a gray-iron casting and cheaply made, cored out and recessed to receive the gear blank, which has been partly turned, and reduced ¼ inch in diameter on the front end, to receive the steel clamping strap *G*, which is bored out to fit on. Three saw slits are milled in *F* marked *I*. When the clamping strap *G* is gripped up by the bolt *H*, the three saw slits allow the chuck to grip the blank securely, the latter being set dead true automatically. The tools shown in Figs. 3 and 4 are then brought into operation, and the front finished to 1 inch thick. The top is then completed by turning by the same two tools which had operated on it before. The blank is then bored and turned complete, and only requires the six ⅜-inch holes drilled in, as shown in Figs. 1 and 2.

For this operation the jig shown in Figs. 8 and 9 was designed, and it being complete in itself no separate clamping bolts are required, a common fault of most plate jigs. *L* is a gray-iron plate, turned up all over, with 6 hard steel bushes *M* let in, and also a 1-inch hole is bored through the center. *N* is the steel clamping bolt, which is turned to be a good sliding fit in *L*, and reduced at the top end, to take the washer *R*, and the nurled thumb nut *Q*. The bottom end of *N* is turned to a taper of 45 degrees as shown in Fig. 11, and the split ring *O* shown at Fig. 10 turned 2¼ inches diameter is bored out to receive *N*. The slit in the ring is shown at *P*. The jig is dropped on the top of a wheel blank, the split ring *O* in its normal position just fitting in the bore of the blank. When *Q* is tightened, however, on *N*, it draws the tapered head of the latter up, and expands *O*, which holds the jig fast to its work, while the latter is being operated upon. The blank is then ready for the gear cutter.

We have drilled several hundreds of blanks on a sensitive drill press with this jig, and find it leaves nothing to be desired in speed and accuracy.

FIG. 1

FIG. 2

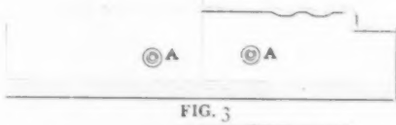


FIG. 3

FIG. 4

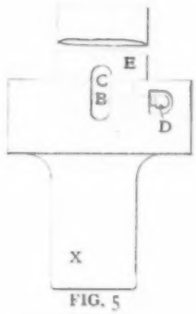


FIG. 5

FIG. 6

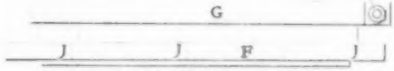


FIG. 7

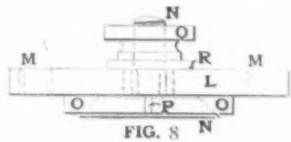


FIG. 8

FIG. 9

FIG. 10

FIG. 11

TOOLS AND CHUCKS FOR MACHINING AUTOMOBILE GEAR BLANKS

A Diminutive Steam Engine

The *Canadian Engineer* describes a claimant for the position of smallest engine in the world, which was made by John H. Cunningham, an Eaton, Indiana, inventor, who has a fad for making miniature machinery. The little engine operates at a remarkable rate of speed under a pound of steam. The screws that hold the parts together are made from needles, the threads being so fine as to defy the naked eye. The screws are a fraction of a millimeter in diameter. The fly-wheel measures ⅜ inch in diameter. It was turned from steel by Cunningham, who says it is the largest wheel that the engine will turn. The engine has 1/16 inch stroke; the cylinder head measures ⅛ inch in diameter, while the capped cylinder measures ¼ inch. The stuffing boxes are packed with lint scraped from silk thread, cotton being too coarse for the purpose.

A strong etching fluid for marking steel tools is made by mixing ¼ ounce nitric acid, ¼ ounce muriatic acid and 1 ounce water.

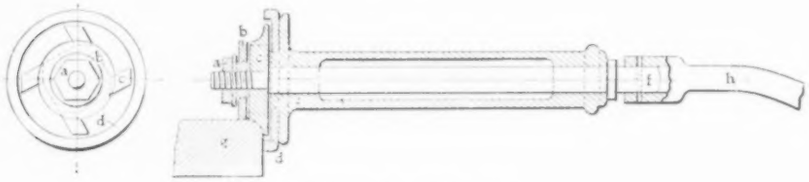
Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

A Corner-rounding Tool for Patterns

The illustration shows a device for rounding corners on patterns. It consists of a handle *e*, which is made of cast iron, as shown in the illustration, with a flange to protect the hand from slipping against the guide ring *d*. In front of this guide ring the cutter *c* is located, which is fastened to the shaft *f* by a nut *a*, which is cylindrical behind the flange. On this cylindrical part the other guide ring *b* revolves.



A CORNER-ROUNDING TOOL

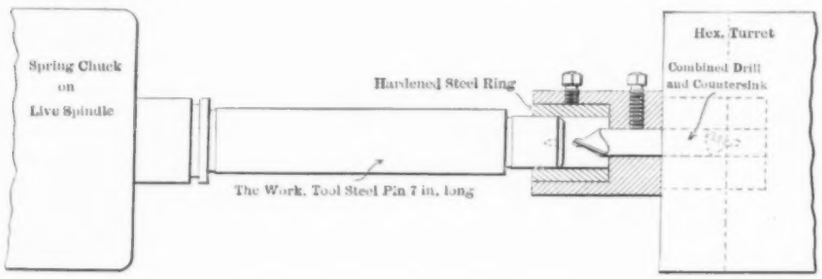
The tool is driven by a flexible shaft *h*, which can be connected to any ordinary lathe by having a center fastened to one end of the shaft to fit the lathe.

This tool will be found very useful on large patterns, as different-size cutters can be put on for different-size rounding.

AMOS L. MUMMERT.

Centering Device for Turret Lathes

I submit a sketch of a device used on screw machines, which I think will be of interest to readers of the AMERICAN MACHINIST. The device is used for centering long work, which is afterward ground after being turned but before cutting off.


Spring Chuck on Live Spindle
Hardened Steel Ring
Hex. Turret
Combined Drill and Countersink
The Work, Tool Steel Pin 7 in. long

CENTERING DEVICE FOR TURRET LATHES

It consists of a tool- or machine-steel socket bored to accommodate a standard combined drill and countersink, which is held by means of a set screw. The hardened steel ring will insure the work running true, and can be replaced by various sizes of rings to accommodate different diameters of work. The other end of the work is centered by reversing and holding in a spring chuck, and centered with a similar drill and countersink.

An advantage which the device shown gives, is that the work will run perfectly true for threading in the geometric die, which is done after centering.

H. LANGBERN.

Molding a Worm Wheel in a Two-part Flask

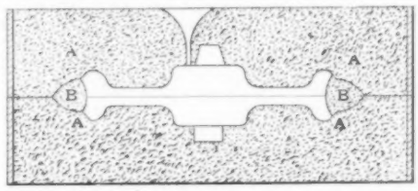
Persecution in the shop or foundry isn't new, but it isn't every man whose dose of nagging shows up his ability, as was the case in this instance.

He was an ambitious young molder and had failed to be frozen out by impositions; and, after having been given all the heavy and long day's work possible for some time, he was handed out a worm-wheel pattern and provided with no three-part flasks, as all usage and custom required.

It happened to attract the attention of the superintendent, so he watched to see if this would be the "last straw," or if the man would have a surprise for his tormentors, as had proven the case sometimes before when it came to a question of knowledge and ingenuity.

The problem did not take long to solve, as shown in the accompanying sketch, and brains against position won again.

The sand carried by the cope and drag is shown in the sections *A A*, while the heart-shaped section ring *B* is free from either and has a parting between both cope and drag. By twice rolling the flask, the pattern is drawn and the mold completed in record time. The castings all went out of the foundry by way of the scales in the morning, and another of those bloodless victories was won. Just a little resource on the man's part and a time-honored custom was dispensed with.



MOLDING A WORM WHEEL

It is perfectly obvious that this treatment could apply to a great deal of three-part flask work, and the only regret is that the man's sole reward was his own satisfaction with a job well done—and the knowledge that the occurrence was noted and appreciated, if he reads the AMERICAN MACHINIST and happens to see this.

LUCIEN I. YEOMANS.

A Soldering Center

It is often desirable to solder pieces together while one piece is held in the chuck or against the face plate. The usual way is to hold the one piece against the other by means of the tail center. This is all right for heavy work, but for light work I use the spring center shown in the cut.

The body *A* is a piece of steel 3 inches long, with a ¼-inch hole through it. *B* is a plug screwed in one end, and *C* is a plug, with a hole through it, screwed into the other end. The pin *D* runs through the plug *C*. It has a shoulder on the end to prevent it from dropping out. The shoulder bears against the spring *E*. The plug *B* has a female center in it which engages with the tail center. The tool is put between the work and the tail center, and the tail center is moved forward. As the pieces are held together by spring pressure the outer piece can be moved to the desired position without any trouble.

A SOLDERING CENTER

F. B. A.

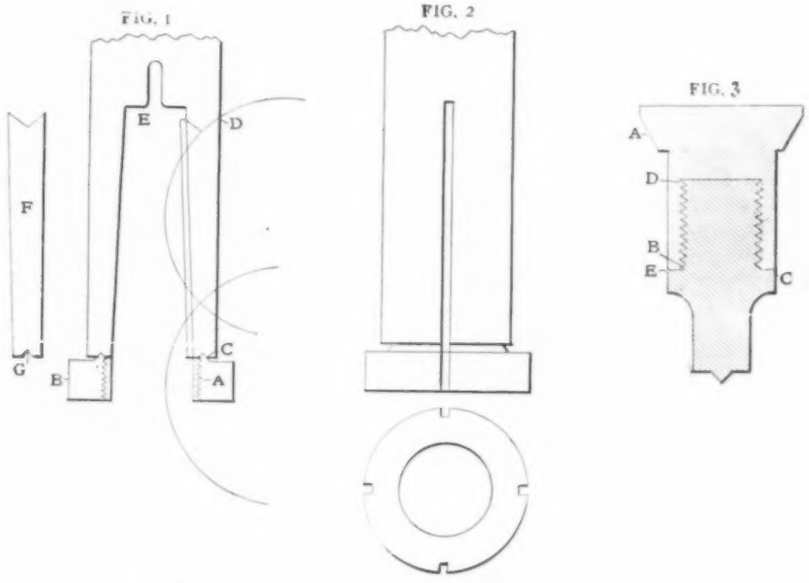
Tool-room Repairs — Drawing Twist Drills—Making Small Punches

Once upon a time when I had charge of a tool room, we had considerable trouble caused by the twisting off of the flat shank on the taper fit of twist drills and rose reamers; in fact all drills having a taper fit. The only way out of the trouble was to mill a slot in the shank and put a feather in the drill chuck. I took one of the standard chucks, turned the end as shown at *A*, Fig. 1, and cut a fine thread on it, then fitted the nut *B*, and on the upper face of the nut turned the V projection *C*. I took off the nut and put the chuck in the milling machine, and with a ⅜ wide cutter, cut through one side of the chuck as far as *D*. Then I used a narrow chisel and file to make the shoulder *E*. From tool steel I made the feather *F* of such a length that the nut *B* will screw up against the end *G*, and forcing it up tight against the shoulders *E D* finished off the outside flush. It makes an unbreakable job, and the nut preserves the contour of the hole. Fig. 2 is the finished product.

Punches

Men who have turned boilermakers' punches for power machines know that it is the general practice to turn an inch punch from the same sized stock as that required for a quarter-inch punch. To save a lot of unnecessary turning I took the stub of an old punch *H*, Fig. 1, faced it off at *E*, drilled and threaded it as shown, and fitted all punches from three-quarter down to this punch holder. On collar *C*, I filed two flat places for the wrench. The punches should have a bearing at *D* and at *E*. The holder is not removed from machine except for sizes over three-quarter, all undersizes being changed by unscrewing. It never gave any trouble.

WALTER DE SANNO.



A METHOD OF DRIVING DRILLS AND MAKING SMALL PUNCHES

Boring-bar Cutters

How many cutters shall we use in a boring bar? Perhaps we might lay down a law that the most economical number was where the increased work, due to multiple cutting edges, exceeded the time spent in grinding and setting so as to bore the same size.

That would look fine in a student's note book and he could probably lay out a curve that would follow the law; but would he know any more as to what to do, when he bucked up against a boring mill and a pile of cylinder castings, than he did before, even if he could repeat the law backward with his eyes shut?

The foreman wouldn't be apt to care two cents about the law, or to stand idly by while the student was trying to figure out the *x y z* of the problem. Of course, if there is only one boring bar in the place, he will use that; but does any such alleged statement of facts help a man a particle?

Coming back to earth, we find that while there is the usual difference of opinion about the matter, many practical boring-machine men use a single point cutter in most cases, and do not see any economy in using more than two in any case. We find, too, that the old flat or square cutter, mortised through the bar, holds its own against all comers, and that even for finishing it has many advocates.

Those who have to do with brass work know how well the flat cutter acts in this work, and for milling brass there is nothing like the single point cutter. It will do more and better work than anything I know of.

FRANK C. HUDSON.

A Handy Die-square

Possibly the readers of the AMERICAN MACHINIST might be interested in the die-square of which I inclose a sketch. In my long experiences as a die maker, I have failed to find anything on the market for this particular purpose. It has been the custom of die makers to file up a square of sheet steel to give the desired clearance; but this is hardly ever a satisfactory method, as while some will be accurate, many are not.

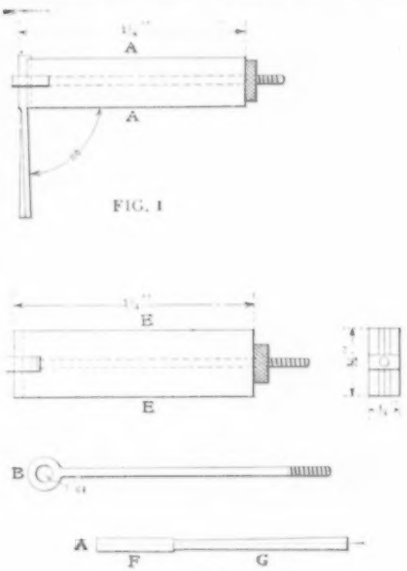


FIG. 1

FIG. 2

A HANDY DIE SQUARE

This square is shown complete in Fig. 1, and consists of a body of ¼-inch steel, ½ inch wide and 1¾ inches long. The edges *E E* should be ground straight and parallel. At one end is a 90-degree V-slot, 1/16 inch deep, to receive blade *A*. This slot must be square with edges *E E* and parallel with the sides.

The blade *A* is ground straight at *F*, where it fits the body. The taper portion *G* is ground central with *F* and at any desired angle. These are held in place by the draw bolt *B* and the milled nut, which is ⅜ inch in diameter, so as to be easily turned between thumb and finger. It is a good plan to have a set of blades, varying by half degrees from straight to three degrees.

I have made and used one of these squares to advantage, and believe it is better than the usual square used. The round blades give a single point of contact at all times and are quickly interchangeable.

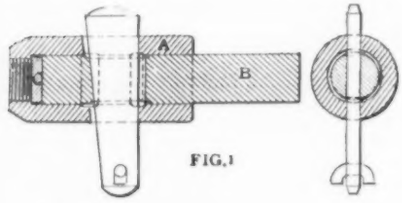
I would also like to say that I have worked in quite a number of shops and have seen dies taken from the grinder and put in operation, with only a careless

wiping with waste, and in most cases not even that. Would it not be a good plan, and prolong the usefulness of the punch and die, to give them a bath in either hot soda water or benzine, after being ground and before being used?

H. M. H.

Releasing Chuck for Threading

The sketches, Figs. 1 and 2, show two styles of releasing chucks used for threading short pieces, such as close pipe nipples, requiring a taper thread cut from each end, one end being threaded before the piece is cut off from the stock material. The releasing feature of these chucks is obtained in the case of Fig. 1 by the use of the taper key, and in Fig. 2 by threading the sleeve *A* and mandrel *B*. Fig. 1 makes the quickest arrangement, and is preferable where the chuck is held stationary; and Fig. 2 makes a safer and neater



RELEASING CHUCKS FOR THREADING

arrangement where the chuck must revolve.

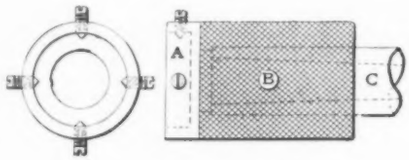
The sleeve *A*, Fig. 1, is counterbored at each end of the key slot, so that any burs formed by the movement of the key will not interfere with the free action of the sleeve on the mandrel. The mandrel *B* is flattened at the key slot for the same reason. When using the key chuck Fig 1 the key is tapped in snug before the piece to be threaded is screwed into the nose of the sleeve *A*. The piece, having been threaded, can be screwed out by hand after backing out the key with a light tap of a hammer. The pin in the end of the key prevents it from falling out of the chuck.

The action of the screw chuck Fig. 2 is similar. The sleeve *A* being screwed on the mandrel *B*, the piece to be threaded is screwed in, and after being threaded is released by backing off the sleeve *A* a thread or two. The disk *C* is a hardened steel washer to take the wear due to the slipping of the pieces when being threaded.

RIWAK.

A Die Holder for the Lathe

The illustration shows a die holder to be used on the lathe. It fits on the tail spindle *C*, and holds the die at *A*. It will cut a true thread, is very rigid, and saves lots of time. *B* is a hole for a lever or spanner. I use the one I have mostly for finishing up to size, after roughing with a tool. All know how hard it is to start



DIE HOLDER FOR THE LATHE

a thread with a die and cut it straight; there is no such trouble with this die.

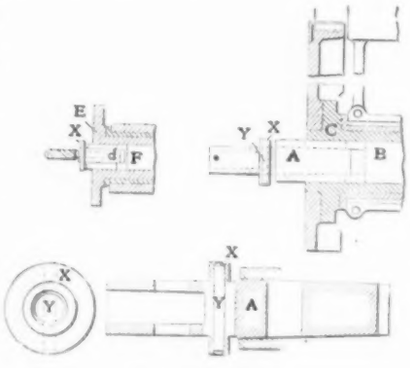
W. T.

A Drill Ejector

To expedite work on a large Niles horizontal boring and milling machine, the improvement on the drill socket marked *A* was applied, and its extreme simplicity and effectiveness won the admiration of all that saw it in operation.

The socket *A* is a standard No. 5 and fitted to the drill spindle *B*. This socket has a loose collar *X* on it that holds the 5/8-inch round pin *Y* in the eye of the socket. This pin slides freely in the slot. This collar and pin constitute the whole improvement. Placing a drill or tool in the socket pushes the pin and collar back close to the drill spindle. The collar is about ½ inch larger than the drill spindle, so that it will come in contact with the spindle sleeve marked *C* when the drill spindle is drawn all the way back, bringing the pin in contact with the drill shank, and forcing it from the socket without stopping the machine. This is a great advantage when it is necessary to run the machine at a high rate of speed, for it saves time and does not ruin the clutches or frictions.

The socket marked *d* is a standard No. 4 with the shank fitted to a No. 5 socket in



A DRILL EJECTOR

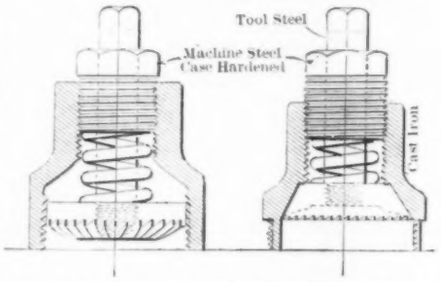
the drill spindle *F*. This is a smaller type of machine, and the socket has a collar *X* fastened to the outer end, which comes in contact with the sleeve *E*, which withdraws it from the drill spindle *F* when the spindle is drawn back. This is far more effective than using a wedge and drawing it out, for it does not jam but forces in a straight line, and does not mar the spindle.

This could be applied to a drill press, especially one with a revolving sleeve in the head. Its cost is nominal. The collar can very easily be removed by driving out the pin.

BENJ. C. NOBLE.

Tools for Facing Injector and Injector-pipe Joints

In a recent issue of your paper I noticed a sketch of a tool for facing globe-valve seats. I send you this sketch of tools which I have seen used successfully in large locomotive shops, and they proved themselves a great time, labor and annoyance saver, for all men working around locomotives know what leaky injector-pipe joints mean. One tool is for facing joints of pipe and is screwed into the nut on the pipe, and with the concave cutter



TOOLS FOR FACING INJECTOR AND INJECTOR-PIPE JOINTS

the joint is faced in a few minutes, doing away with all filing and scraping, copper washers, etc. The other tool is for facing the ends of injectors, which get battered. This tool quickly faces them up and gives correct radius to the seat. The teeth of the cutters require to be brought to a fine keen edge and left very hard. Flat cutters can be used if required. The spring gives a nice easy tension in the cutter.

P. C. R. RY.

Obtaining Machinists Under False Pretenses

Under the alluring title of "Machinists are Well Paid" the Chicago *Tribune* uses a lot of space to spread such misinformation as this:

"His age runs from 22, which is the age of the near genius in the craft, to 72, when he is a veteran of 50 years' experience, gray-headed, spectacled, bowed and efficient. There is a man with a crooked spine who draws $80 every week he works, because he, and he alone, in a force of a score of employees knows just how a new wool-carding machine should be set up, and he can do the work with his own hands. His crooked back doesn't hurt

him, either, in the opinion of his employers or his employers' patrons. He can make the machines that his firm sells "run." It wouldn't make any difference if he was bereft of his hands and did the work with his toes; the thing is, he does it. Incidentally he got his crooked back through breaking in, or rather trying to break in, a new man in the trade. The apprentice turned on the power before the last nut was tightly screwed on. So one of the many pieces of the machine, operated at a speed of 200 motions an hour, tore loose and struck the expert. He was incapacitated for two months, and his firm lost much money because of it."

I had an idea that the supply of mechanics was running shy, but I didn't know it had reached the stage where they had to be obtained under false pretenses, with $80 and $100 a week dangled before their eyes as bait.

I've worked in some pretty poor shops at various times, but none of them ever turned out machines that had to be nursed and coddled by an $80-a-week man, or that would tear themselves apart at the terrific speed of 200 motions an hour (less than four a minute), even if an apprentice left off about all the nuts on the machine.

Think of a machine "so intricate that to thoroughly master it is often the work of a lifetime," and then ask yourself where the men or women are who will operate it after the "expert" gets through. The chances are there will be seven new hands a month on it, and half of them won't know whether it is an "intricate piece of mechanism" or an ice-cream freezer. The kind of a machine you have to make to put in the average shop or factory must be capable of being handled by ordinary labor.

I know there are too few apprentices, especially those who stick to the job long enough to learn how to do things; but it doesn't strike me as a square deal to coax a boy into the trade by making him believe there's a chance to earn $100 per by fussing with a machine that "no one else can adjust as it should be."

The machinist trade is all right. I like the work, would like the pay better if there was more of it; but though the boss counts me a pretty decent sort of a workman who can also handle men, he'd have seven kinds of apoplexy at once if I intimated, ever so gently, that $100, or even $80, per was about my size.

FRANK C. HUDSON.

The Automatic Feed Inventive Problem

Herewith I present a solution of the problem at page 122. Referring to the sketch, Fig. 1, the sleeve *H* is held in stationary position by two bars *I* and *I'*, the gear *J* being screwed on it and locked as shown. The stud *S* is fixed in the cylinder *A* and carries gears *K* and *L*, which are locked together. The gear *K* meshes in the gear *J* and is of the same number of teeth, in this case 44. In one revolution of the cylinder *A* the gears *K* and *L* also make one revolution.

The gear *L* meshes in the gear *M*, which runs idle on the screw *C* and has 40 teeth, or 8 × 5. The gear *L*, by having 48 teeth, or 8 teeth more, advances the gear *M* by 8 teeth, or ⅕ of its whole number, every revolution.

By engaging the clutch *N* in the gear *M* the screw is put in motion. All gears are of 14 diametral pitch. The reverse feed could also be attached.

Baltimore, Md. J. A. SVEJDA.

[Another solution of this problem is based upon the same principle, but is not so completely worked out. It is unnecessary to reproduce the sketch, but part of the letter is given below. The gear referred to in the first sentence corresponds to Mr. Svejda's *J*, but it is placed on the hand-wheel side of the gear on *C*, which latter gear is permanently pinned to the screw-shaft.—Ed.]

" . . . . The gear is loose on shaft *C* and is kept from turning by a suitable lever resting on some point of support outside the mechanism, as even Archimedes could not move the earth without a fulcrum. This support should be in the form of a rod, held parallel with shaft *C*, and of such length that the lever can slide upon it throughout the length of the feed, and drop off the end when the cylinder has been fed in far enough. The rod must be arranged so as to be readily swung out of the way to allow the screw to be turned back by hand.

"O. B. Server can probably adapt the change gears from some small lathe if he wishes to try this experiment; and, the ratio of the gears being a simple mathematical problem, he can doubtless work it out as well as I can, or better.

STRAWBOSS."

[A third solution on the same general principles as the preceding two has been received, but it has a somewhat different disposition of the parts. We reproduce the business end of the drawing and part of the letter, omitting the description of the action of the mechanism, as we believe that will now be sufficiently clear. —Ed.]

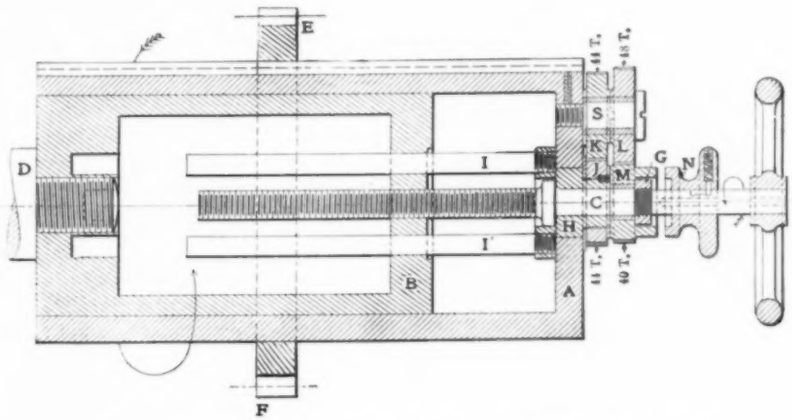


FIG. 1. MR. SVEJDA'S SOLUTION OF THE AUTOMATIC FEED PROBLEM

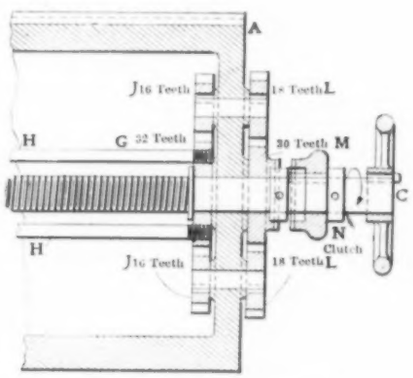


FIG. 2. MR. STEERE'S SOLUTION

" . . . . The clutch can be thrown out of mesh at any time and the cylinder operated by hand. It would be better to make a friction clutch, so that when the cylinder is driven too far the clutch would slip and nothing be broken; or, better still, by adding another planetary gear, an automatic quick return can be obtained which would give a constant reciprocating longitudinal movement to the cylinder *a*, entirely automatic and requiring no attention. I can guarantee this direction of rotation only when the planets *L*, Fig. 2, count out, in one revolution about their meshing gear *M*, more than the number of teeth existing on the circumference of *M*. I know of no other solution of this problem, and give it in the hope that it will be of service and call forth other and better solutions. CLARENCE E. STEERE."

William G. Marr, Springfield, Mass., sends in a solution practically identical with that of Mr. Svejda, only that instead of a clutch to disengage the feed, Mr. Marr forms a handle on the hub of gear *M* so that this gear may be slid out of mesh with the gear *L*.

Regarding the interesting problem set forth at page 122, the accompanying sketch, Fig. 3, illustrates a method of obtaining the desired relative motions.

A is the revolving cylinder, *B* a pinion of 15 teeth keyed into the cylinder, and loose on the feed screw; *C* and *D* are wheels of 25 and 16 teeth, respectively, keyed together and revolving loosely on stud *E*. *B* and *C* mesh together. The stud *E* is mounted in lever *G*, which is prevented from revolving by weight *H*. The pinion *D* meshes with an internal gear *F* of 48 teeth, which is mounted loosely on the feed screw. On this internal wheel is keyed the ratchet wheel *J*, which by means of the pawl *K* drives the hand wheel *L*, thus driving the feed screw.

The wheels *B* and *C* are 10 diametral pitch; *D* and *F*, 8 diametral pitch.

All the conditions enumerated are fully complied with, viz.:

The screw revolves 1/5 revolution per revolution of *A*, and in the opposite direction to *A*.

The mechanism is kept within the diameter of *A*.

The feed is easily disengaged for returning by hand by the handle *M*.

It will be noticed that the mechanism has been kept small to keep the weight *H* within the defined limits. Had there been nothing to prevent it, the lever *G* would have been better held by a stud attached to some other convenient part of the machine.

I send also, Fig. 4, another solution to this interesting problem. The principle involved is exactly the same as that of the solution just described, the only difference being the substitution of bevel for spur gearing so as to do away with the necessity for an internal wheel.

Pinion *B* of 18 teeth, 8 diametral pitch, drives wheel *C* of 30 teeth. Keyed to *C* is pinion *D* of 15 teeth, 6 diametral pitch. *C* and *D* revolve loosely on stud *E*, which is prevented from rotating by weight *F*. Pinion *D* drives wheel *G*, which has 45 teeth. Keyed to *G*, as before, is ratchet wheel *H*, which drives, through catch *K* and pin *J*, the hand wheel *L* which rotates the feed screw. Catch *K* is thrown out of gear for returning, by handle *M*.

Such problems are always interesting, but examples such as these could be multiplied *ad infinitum* did everybody who runs up against such things think them of sufficient interest to ventilate in your columns.

W. Owen.

Weaste, England.

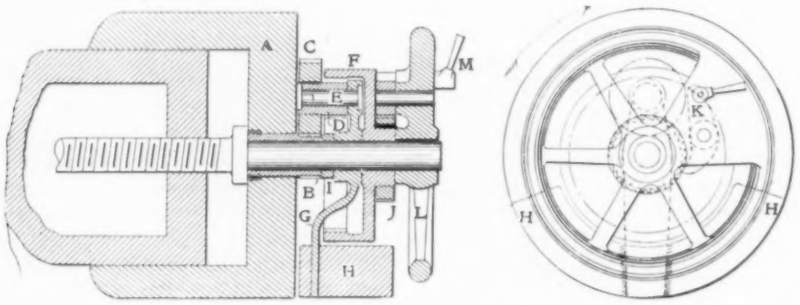


FIG. 3. MR. OWEN'S FIRST FEED DESIGN

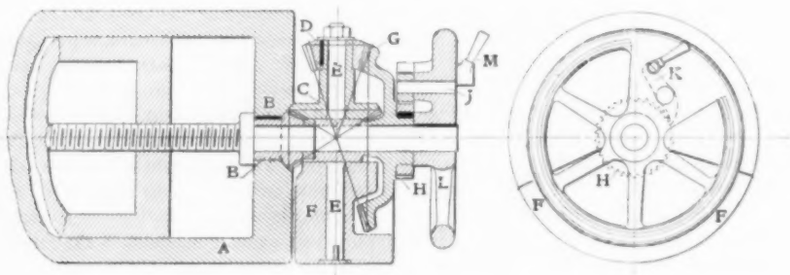


FIG. 4. MR. OWEN'S BEVEL-GEAR FEED

A Method of Milling a Heart-shaped Cam

Some time ago it was found necessary to make a heart cam as a feed for a coil-winding machine, in which the coils were required to be wound smoothly. The first cam made was carefully laid and drilled around the outline, and the outer part broken off, and it was then filed to the line. When this cam was tested there were found to be numerous small errors which caused the wire to overlap and wind unevenly.

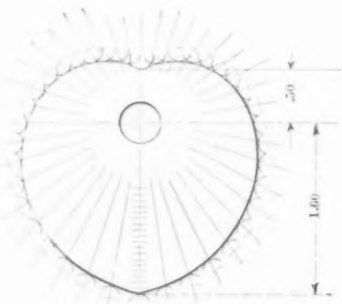


FIG. 1 Method of Laying Out.

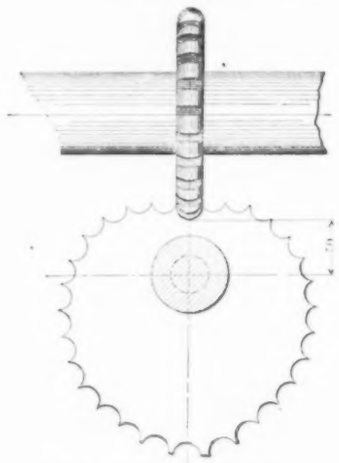


FIG. 2 Position of Cam and Cutter when Commencing to Mill

METHOD OF LAYING OUT HEART CAMS

It was then proposed to make the cam in the following manner: Lay out the curve of the cam roughly, as in Fig. 1. Drill and remove the outside stock, being sure to leave sufficient stock to overcome errors in laying out. Put the cam on the nut arbor and tighten securely. As the roll of the cam is ⅛ radius, select a milling cutter having the same radius. This may not seem necessary, but as the roll of the cam must come to the lowest point it will readily be seen that it would not be able to do so if a cutter of a smaller radius than that of the roll were used. It would also make a difference to the other points on the curve of the cam, which is not quite so apparent at first glance.

Selecting an Index

The next operation is to place the cam between centers on the milling machine, having the cutter in line with the vertical radius of the cam, at its lowest point. Next choose an index circle which will give a division of the cam such that the rise of each division will be in thousandths of an inch, if possible. For this cam we take a circle which will give 200 divisions. As this will make 100 divisions on a side, the rise of each division will be 0.011 of an inch. Now raise the table to the required hight, starting at the low-

est point of the cam, and mill across, as in Fig. 2.

Moving the Table

For the other cuts lower the table 0.011 each time, and revolve the cam one division until the highest point of the cam is reached, then raise the table 0.011 for each division of the cam.

When the cam comes from the milling machine there will be found to be small grooves left between the cuts. These may be easily removed by smoothing off with a file without impairing the accuracy of the cam.

Most screw-machine cams can be made in this manner, and they will be found to be more accurate than if laid out and filed to the line, and also much easier to make after one has become accustomed to the method. Fred R. Carstensen.

Some Arithmetical Short Cuts

It is likely there are a good many readers of the American Machinist who are not quick at mathematics or expert with the slide rule, and who occasionally have to determine results and are ready to adopt any short cut that will help them out.

There are short cuts that are not absolutely correct, and whether they should be used or not depends upon whether the result is as accurate as is required. The relation of the side of a square to its diagonal is approximately as 7 to 10, that is, it is within a small fraction; and whenever this ratio is used to determine a measurement on a drawing, such as the diagonal of a ⅞-inch square bolt head, and the resulting 1¼ inches is nearer than the draftsman can work, or needs to work, the short cut is good enough. So, too, the circumference of a circle is as 22 to 7

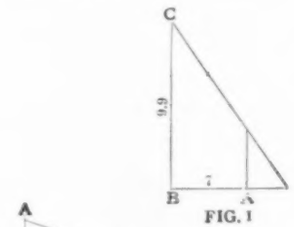


FIG. 1

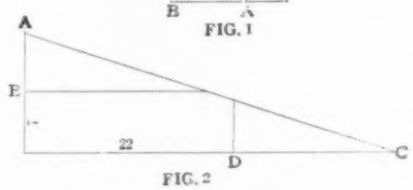


FIG. 2

SOME ARITHMETICAL SHORT CUTS

within 0.00001, which is far within the limits of a draftsman's ability to work, and probably far more accurate than can be obtained by the slide rule. These ratios, that is, 7 to 10 (or almost exactly 7 to 9.9) and 7 to 22, permanently drawn on a draftsman's drawing board (see Figs. 1 and 2), enable him to instantly determine the circumference of any circle within the range of the diagram or the diameter of any circle of which he has the circumference, or, from the other triangle, to determine the distance across the corners of any square within its range.

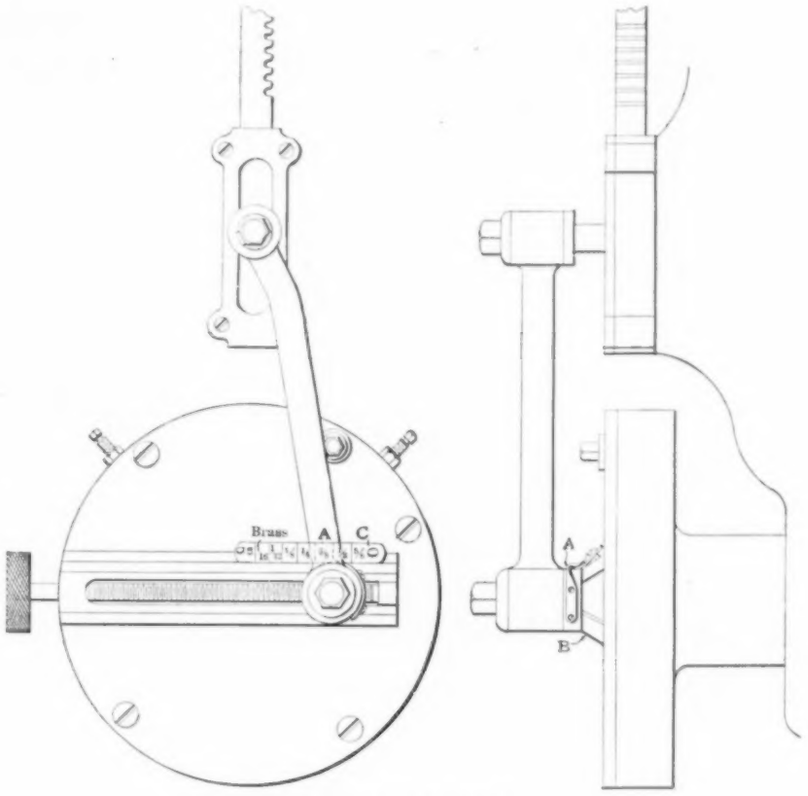
That is to say, if he wishes to know the distance across the corners of a 2¼-inch square he has only to measure off from the foot of the diagonal, as at *A*, Fig. 1, 2¼ inches, strike the vertical parallel to the original line *B C* and the length of the new line is the distance required. In the case of the circumference of the circle, if the diameter is laid off from *A*, Fig. 2, down the vertical, as at *B*, and the horizontal parallel to the base is drawn through *B*, the length of the new line is the required circumference; or, if the circumference is known and the diameter is required, measure the circumference from *C* on the base line, as at *D*, strike the vertical and its length is the diameter. A second advantage in these diagrams is that, no matter what the measure or how fine the fraction, the result is obtained just as readily as with whole numbers, whereas, with the slide rule, everything is in tenths.

When the measure wanted is small in proportion to the triangle, it is only necessary to use large units for the small ones needed. In making drawings to scale, say one-quarter size, we use small units to represent large ones, and in this case we can reverse the thing and use large units for small ones.

John E. Sweet.

A Planer Feed Indicator

The illustration shows a little device invented by me for indicating the feed on a planer. I have been using it on a large Niles planer for the past year, but it can be adapted to any make of machine, using the frictional, oscillating feed disk.



A PLANER-FEED INDICATOR

The illustration shows plainly what it is, and needs but little explanation. The pointer *A* is attached to the sliding block *B* and can be easily adjusted to the required feed. I have found this much handier and quicker than the "cut and try" method ordinarily used, especially where there is great diversity of work, necessitating frequent change of feed.

Harrison.

In addition to chemical operations and dye manufacture molybdenum has been of late used in steel with the effect, when employed in quantities up to about 4 per cent., of giving the steel hardness and toughness, which are not diminished by heating and welding. The mineral has been found in British Columbia.

In Germany much attention is being given to the preservation of wood by sulphur applied in the liquid form; it hardens and completely fills the cell spaces of the fiber. At moderate temperatures water, acid or alkaline solutions have little effect on the sulphur, though at a high temperature it oxidizes readily. The most suitable wood for the treatment is poplar, oak or pine not being so good.

Molding a Large Jig Casting

Molding Entirely in Cores. Dividing Up the Cost between the Foundry and Pattern Shop

BY JABEZ NALL

In making such a casting as the one shown in Fig. 1, of which only one is expected to be made, the first consideration should be of entire cost in both pattern and foundry departments combined.

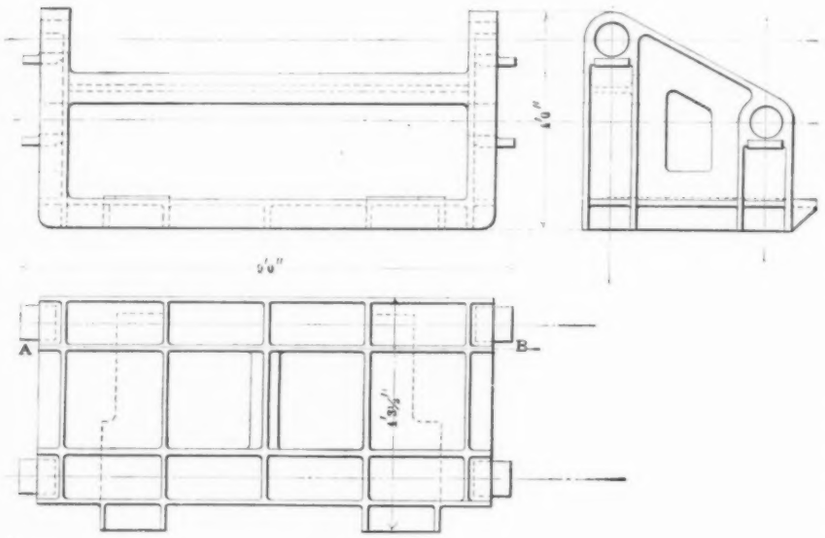


FIG. 1. THE JIG

With this in view, it was decided that the mold be entirely formed in cores; this proved successful. The ends of the castings were formed by the cores *A* and *B*, made from the box, Fig. 2, shown in plan and detail section on lines *A* and *B*. In order to reverse, parts *L* and *M* are made separate and screwed to the bottom board, on the correct centers, and pieces inserted between them to form the required shape. The lower parts can be nailed down, but the pieces *N*, *O* and *P* are left loose in place and the rib *Q* is screwed to the parts *L* and *M*. The drawing as shown is for core *A*; to reverse for core *B*, Fig. 8, all that is necessary is to unscrew the rib *Q*, place the parts *L* and *M* on opposite centers, again screw on the rib *Q* and turn over the pieces *N*, *O* and *P*.

The cores *C*, *D*, *E* and *F*, Fig. 8, forming the center body of the casting, are made in the box, Fig. 3, which, as drawn, shows the core *C*, except that a piece must be inserted at *A*, Fig. 3, filling the space, the bracket *D* being shown in position and in detail below.

To make the core *F*, the pieces *R*, *S* and *T*, Fig. 3, which are loose in the box, are placed on the opposite side, the bracket *D* is taken out, and the bracket *E* placed at the opposite side of the box also. The core *D* is made as shown with the bracket *E* and the piece *A* taken out of the box.

For the core *E* a strip the thickness of the rib is placed above the rib to the top edge of the box; also, a piece is placed at each end, thus narrowing the box by the thickness of the rib, and the piece *B* is turned over and placed on the opposite side of the box. The core *G* is formed in the box, Fig. 4. Eight of these cores are required, four right- and four left-hand, as regards the hooks in the cores only. The core *H* is a full round box, half of which is shown in Fig. 5. Four of these are required with small, dovetailed babbitt cores, nailed on.

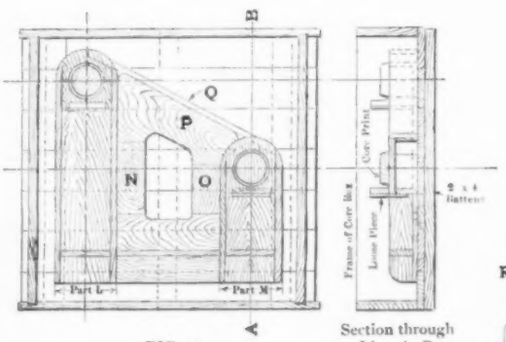


FIG. 2 Section through Line A–B

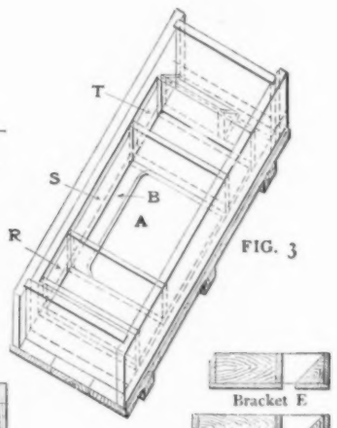


FIG. 3

FIG. 4

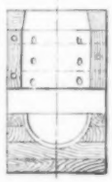
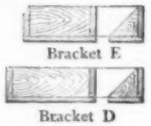


FIG. 5



CORE BOXES

Covering or Slab Cores

One each of *1a* and *1b* are formed in the box shown in Fig. 6. As drawn, it shows the core *1b*. To change for the core *1* the piece *b* is removed from the facing *a*, which is turned over and placed on the correct line for the opposite hand. The core *1a* is a plain slab core, with facings removed entirely. The slab cores *2*, *2a* and *3* are formed in the box as shown in Fig. 7, which, as drawn, is arranged for the core *3*.

For the core *2* the piece *a* is removed. The core *2a* is the same as the core *2*, except that the coremaker must be instructed, when making this core, to turn the box over in order to finish the opposite side of the core *2*. Also, instructions should be given him as to the placing of hooks and vents, arrangements for gates, risers, etc.

The cores now having been made and dried, we are ready for the molder. Owing to the shape of the casting, the length and width of the metal in the bottom, and the hight of the sides giving so great a pressure on the bottom, it is best that this be made in a regular screw bed, with its

binder plates below, and beams above the mold.

A hole being dug of sufficient size and depth to bring it well below the floor line, and the cinder bed having been examined, or being known to be in good condition, a level bed of sand is then made above this and the cores *C*, *D*, *E*, and *F* are laid on this, abutting each other, and placed in alinement, as shown in Fig. 8. The cores *A* and *B* are next stood up at each end and set square with the bottom cores, and temporarily braced. The cores *H* are inserted in their respective prints, and secured to the back of the core *A*, or the core *B*, as the case may be. The cores are now brushed off, and any dirt or loose sand is removed. All necessary holes for hooks, etc., are filled in. The cores *1*, *1a*, and *1b* are next placed in position. It will be noticed that dividing this space into three, while below we have four cores, crosses the joints, and thus helps to hold the cores in position; also, it gives each of the three slab cores a bearing in the center on the parts *D* and *E* that cut through the metal, whereas, otherwise, the two outside cores would have bearings on the ends only. These cores being placed, the cores *2* and *2a* are placed on edge against the cores *A* and *B*. Sand is then laid on the bottom slab cores about an inch deep; on this are placed plates to strengthen the cores, and allow for the binding posts, four of which are used, as also two iron blocks over the cores *G*. A ramming is then made around the outside, and the gates cores are placed as shown in section, Fig. 8. Two gates are used connecting with the two inside longitudinal ribs, giving a straight flow for the metal. The outside is then rammed up to the hight of the top of the plates. Other plates are placed along the side of the cores *2* and *2a*, and braced by two pieces of wood about 4x4 inches, cut to exact length to prevent any straining of the mold. Then the whole is rammed up, inside and outside, to the hight of the lower sections of the cores *2* and *2a*. The offset in these cores gives the position of the cores *G*. This portion is properly leveled, and a channel cut and filled with small cinders, to carry off the gases which are piped to the outside of the mold. The four former halves of cores *G* are then placed in a straight line between the cores *A* and *B*. These being in position, the upper halves are placed on these, and the mold rammed to the level of the top of these. The cores *3* are now placed alongside the cores *A* and *B* and braced in position, plates laid over the cores *G*, and iron blocks placed on these to the hight of the binding post. Plugs for the riser are inserted in holes already arranged in the cores *A* and *B*, at the highest point of metal. The mold is then rammed to the full hight, the runner basin made, and rails laid on the binding posts and blocks, above which come the regular binder beams, which are secured and screwed down in the usual way. This being done, the rails are securely wedged under the beam. The usual arrangements are made for overflow, etc., and we are ready for first iron.

On the whole this produced a cheap casting, the pattern-shop expense being small, and it was very largely machine work. Expense in the foundry was small also, as all plates, binding posts, blocks, etc., mentioned are common foundry stock. This being practically a dry-sand mold, I can see no reason why this method used in other cases should not result in a clean, sound casting, as it did in this one.

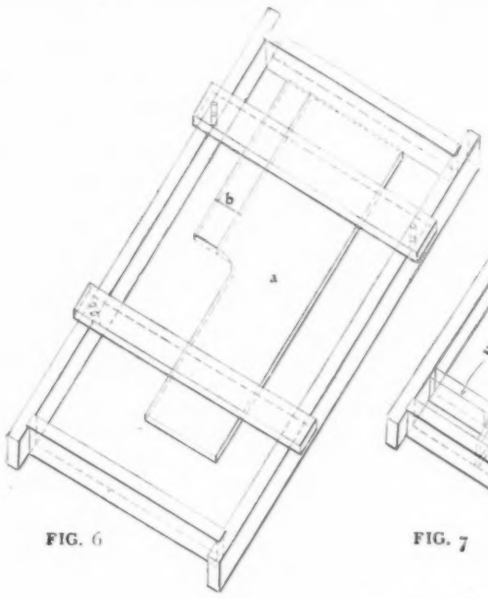


FIG. 6

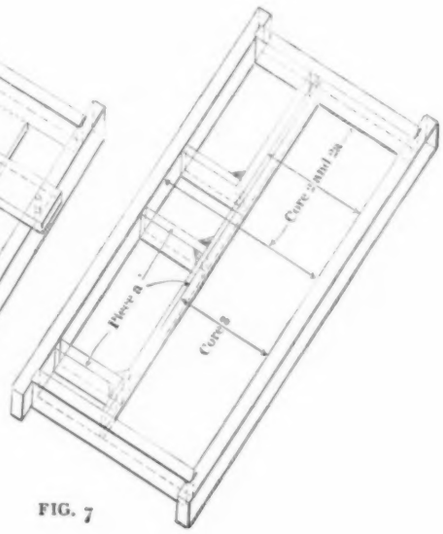


FIG. 7

CORE BOXES

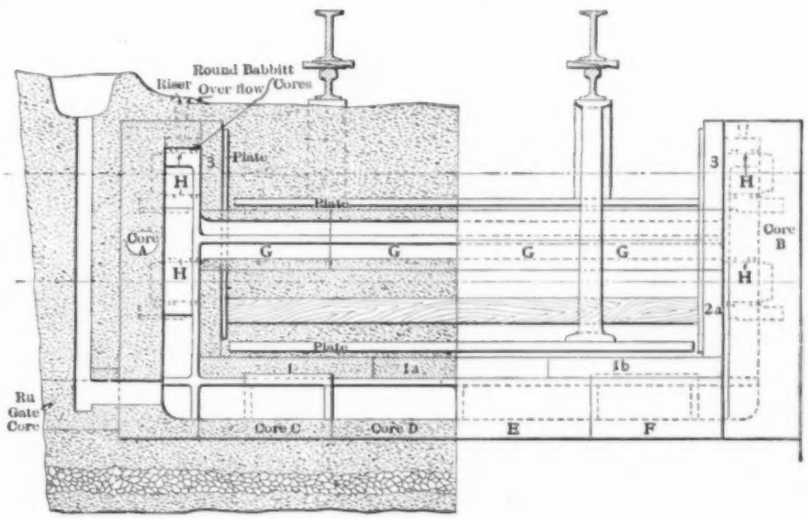


FIG. 8. THE MOLD

The Professional Educator and Trade Schools

By E. R. Markham

We are taught that confession is good for the soul; and I for one am always pleased to know that a man is sufficiently broad minded to acknowledge he has been in error. I was particularly pleased when I read the confession of Entropy at page 238.

Men in any given walk of life are apt to hold lightly the ideas of others, when these ideas conflict in any way with ideas they have held, and especially if the other fellow's experience has not, in their estimation, warranted him in expressing an opinion.

The Shop Man Becomes Instructor

An experience of 25 years in shop work, a goodly part of which time was spent in charge of work, gave me an idea that any education so far as shop methods were concerned could not be gained anywhere but in a shop, and that any time spent elsewhere was worse than thrown away. Several years ago, much to my own surprise, I was offered a position in a manual training school. At first I laughed at the

idea that a man whose whole past life since leaving school had been spent in active work, in producing commercial articles, in planning the policy of shops, should engage in school teaching. Nevertheless, conditions were such that I finally accepted the offer. It is needless for me to say that my ideas have undergone a change; things that I once looked upon as foolishness I now consider of the utmost importance.

A Harvard Professor

Entropy's estimate of Professor Hanus, of Harvard University, is, I am sure, shared by every fair-minded man who has heard him speak on the subject of industrial education. He has made a study of the subject, and realizes, as one who has never investigated the conditions cannot realize, the burning need of some means whereby the youth of our commonwealth and of our country may not only be taught to apply themselves to some avocation, but may also be given an opportunity to become skilful in the particular line of work they choose to take up.

Factors in Education

The value of manual training, or the higher technical education, depends first on the method employed in presenting it, second on the instructor, and third on the recipient. The same holds true in the shop. To be sure the apprentice has experience on practical work, but the character of the work varies, and those of us who have employed large numbers of men know that many men who call themselves journeymen machinists, and who have given the years of their apprenticeship to some manufacturing concern, have actually thrown away much of their time.

The Foreman's Responsibility

The work given them was not of a character that tended to make finished workmen of them; or the foreman didn't know the proper methods of doing; or his time was so occupied with making money for the company that he had no time to devote to the apprentice. Of course we all acknowledge that the welfare of the concern in whose employ he may be should ever be uppermost in the foreman's mind, and always will be, if he is an honest man. Then again a foreman may know how a piece of work should be done, and not be able to instruct others. He is chosen to the position he holds on account of his executive ability, and not on account of his interest in young men, or his desire to impart knowledge to them, or his ability as an instructor.

Articles and Lectures on the Subject

The subject of industrial education, or, as we understand it, the teaching of trades in schools specially equipped and run for the purpose, has been of interest to me for a number of years, and I have accepted every opportunity to listen to lectures, debates, and informal talks on the subject, and have read the opinions of men who have given the subject more or less attention.

Many times the author or the speaker has had but a vague idea of existing conditions, or the possibilities of such education, and as is generally the case under such conditions images were set up and then knocked down. Such arguments, while in themselves of little consequence, have a tendency to bias some who are not familiar with the subject. At the same time they give someone else the opportunity to correct such impressions.

Education and Educators

Association with educators—and this association has covered a period of several years—has convinced me that there is a difference in educators as in men in all callings of life; and I know that the educators who are most vitally concerned in the present movement are broad-minded and are alive to the fact that the success of such education depends on the men who may be called upon to give the necessary instruction.

I recently met the secretary of the board of industrial education of our State (Massachusetts), and, having in mind the excellent article by Entropy, I availed myself of the opportunity of inquiring what class of men would be considered for instructors, when schools for industrial education were established in our commonwealth.

Qualifications for Instructors

I was informed that the first qualification would be a thorough knowledge of the trade he was to teach, and such knowledge must have been gained by actual experience; in other words, he must be a journeyman tradesman. Second, would be taken into account his ability to give instruction to others; and third, his general education.

I am sure the above statement by the secretary of the board will set at rest any fears that may be entertained by some that incompetent men would be placed in such schools on account of a merely theoretical education. The commission has studied the subject from all sides, and I am sure will not make the serious mistake of appointing men to positions where they would be called to teach a subject they did not understand.

Practical Teachers

A man could not successfully teach blacksmithing in such a school unless he was a practical blacksmith, and thoroughly understood how such work is done in commercial establishments; and he must also be qualified to impart his knowledge to others. The same holds true in the pattern shop; and in the machine department, unless he is a practical machinist with an up-to-date knowledge of modern machine-shop methods, he could not prove other than a complete failure.

The successful instructor must be master of his subject, must be one who has by experience and study dug down deep into the things that are not known to the rank and file of men in the trade. However, this knowledge will prove of little value to others unless he possesses the faculty of imparting it in an understandable manner.

The Shop and the School

In the ordinary shop the apprentice may be fortunate enough to work near some journeyman who takes sufficient interest in him to give him first the points he may need, and even though the foreman may not have time to devote to him, he may get along very well. But, in many instances, the man the young apprentice takes to, and who takes to him, is not one qualified to give him the best possible insight into the case in hand.

In the school the product is the pupil, and the instructor must give him his whole attention; by this I mean all the attention necessary to produce the best possible results, but not to the extent that the pupil would depend entirely upon him, and fail to become self-reliant.

The instructor must, of course, be a man of good moral character, and coming in constant touch with the young man, his influence must be for good in all cases. As stated by Entropy, there are no text books from which the young man may learn. The instructor must be an *instructor* in the fullest sense of the word.

A Trade-school Advantage

A decided advantage to be gained in such a school consists in the fact that in all probability such mathematics, physics, and other branches as are directly necessary to the proper teaching of the trade, would be a part of the instruction given.

I am sure such institutions could be conducted, and am confident they will be conducted, in such a manner that manufacturers and workmen together will pronounce them blessings to our State and nation. I do not say that mistakes will not be made—what great venture was ever started without mistakes being made? But let us one and all make an effort to be helpful to the men who are interesting themselves in this work.

The feeling is growing in Germany that the traditional hospitality of her universities and other educational institutions, which heretofore have been open freely to the students of every land, should henceforth be limited, and, in some institutions, foreign students are required to pay higher tuition rates than are German students.

Drawing Boards with a Steel Edge

By Gerald E. Flanigan

Drawing boards are frequently made, as in Fig. 1, with a steel bar along the working edge, which is presumed to be ground straight within small limits of error. This presumption may be justified as regards the bar itself, but when attached to the board in the manner shown it is refinement thrown away. The bars should be heavy and broad enough to be sufficiently rigid when fastened by the end screws only, and these are all that should be used. The bar will then maintain its straightness and not follow the warping and twisting of the board due to atmospheric changes. There should be a slight clearance, as shown at *A*, so that the wood cannot bear against the straight-edge and curve it outward.

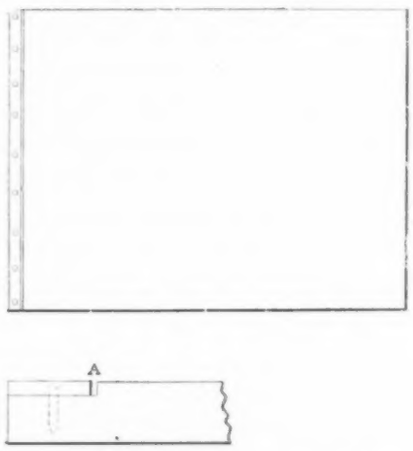


FIG. 1. THE WRONG WAY OF PUTTING ON STEEL EDGES

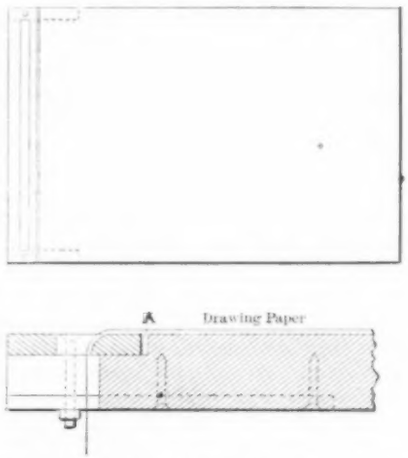


FIG. 2. THE RIGHT WAY—ALSO ALLOWS FOR LONG DRAWINGS

Arranged for Long Drawings

The slotted bar shown in Fig. 2, is designed to admit of long drawings being made on a short board. These bars are frequently fastened by screws at short intervals along the inner edge, but the shrinkage of the wood is sufficient to spring the outer edge of even a bar of this form, and it is much better when attached by only a single bolt at each end. Short steel bars are screwed to the under side of the board projecting outward to support the straight-edge, as the slot in the latter must clear the end of the board.

A Difficult Steel Casting

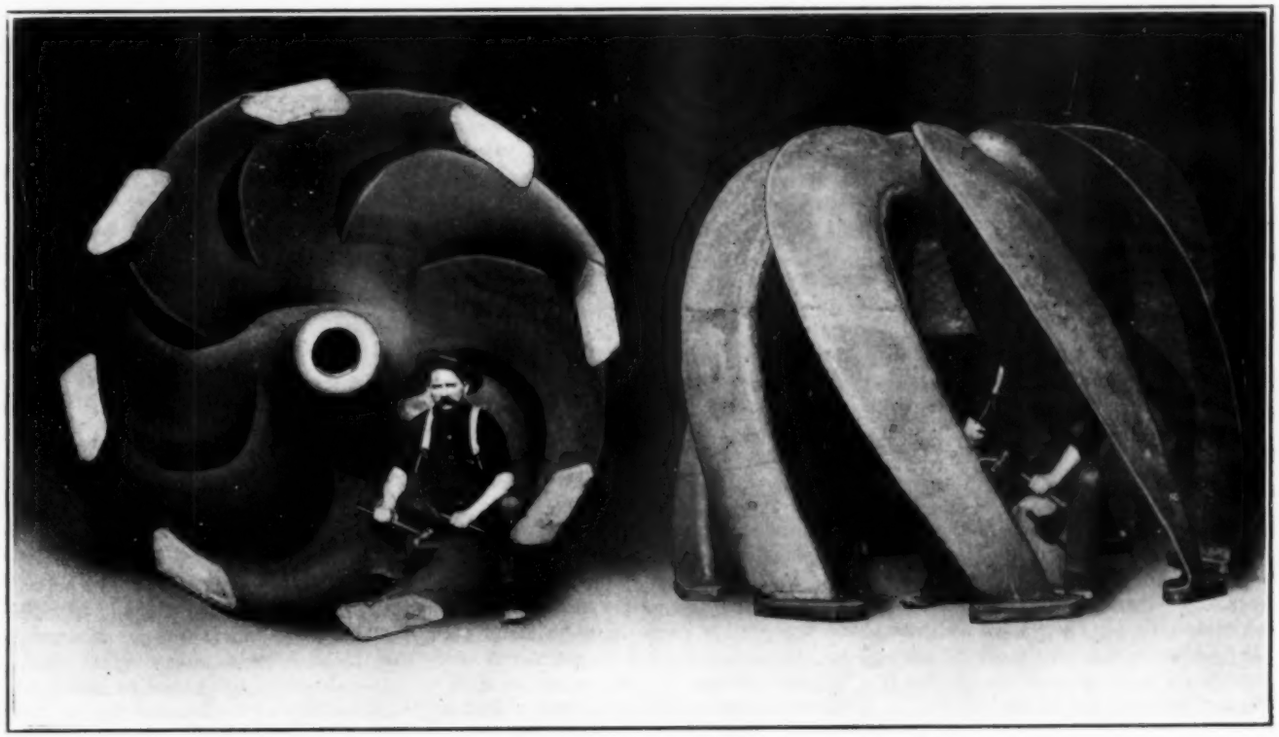
By John Gregson, Jr.

This casting was made by the Pennsylvania Steel Company, Steelton, Penn., and weighs 10,540 pounds. It is a cutter for a suction dredge, built at Providence, R. I., for the United States Government, and is one of the most intricate large castings ever made in steel.

Its hight is 6 feet, and its diameter 7 feet 6 inches. Each blade is wedge-shaped, and runs in a spiral from the hub to the base, where the blade is 2½ inches, tapering to a point in 13 inches. It here joins a plate at right angles, the plate being 9 inches at the bottom by 7⅛ inches thick, conforming to a circle 7 feet 3 inches in diameter. The hub is lightened by a heart-shaped chamber, 7¼ x9½ inches by 2 feet 3½ inches. The blade at its highest point is 18½ inches wide, tapering from a thickness of 4½ inches inside to a knife edge.

How It Was Molded

To mold this "Octopus" so that a sound casting would be produced by the first trial was no mean task. The working material for the foundry consisted of five core boxes, and the mold when ready to pour represented 19 cores rammed up in a flask 12 feet square by 11 feet high. Only two men at a time could be worked to advantage, and as it was a good day's work to ram up a single core, almost four weeks were consumed in assembling the parts. The chief difficulty was the



A DIFFICULT STEEL CASTING—CUTTER FOR LARGE U. S. GOVERNMENT DREDGE

setting of the last nine cores, which formed the top of the blades and the hub. Each core stopped off its neighbor, and the hub core stopped off the whole. To complicate matters, the hub core could not be the last one placed, on account of the chamber, so it was impossible for the molder to be sure that the last core fitted. That the casting was true to model when completed, therefore, was largely due to the accuracy of the core boxes furnished by the Gobeille Pattern Company; and, in addition, it was without settles or shrinkage cracks. It is, on account both of its intricacy and its size, a notable example of what can be done today in a steel foundry.

A Tool-block Holder for Boring Bars and Bolt Cutting

The tool-block holder, shown in the lower right-hand corner at Fig. 3, possesses advantages all its own over most that are generally found. It is very solidly built; the fixed jaw *H* is at the outer end, and the sliding jaw *I* meshes into the jaws of *H* the same as some types of drill chucks. The bar at the top is fixed in *H* and guides jaw *I*. These jaws will clamp a boring bar so that any shake or spring comes from the cross slides or the bar itself, and not from the holder.

For use in cutting long bolts there is a rod holder which goes with this, the shank *G* being square and held in the jaws *H* and *I*. This shank is not gripped tightly, but just so as to allow it to slide freely. The jaws *F* work in the body *E* and grip the rod *D*, as shown.

The die *C* is held in the case *B*, which is driven by the two studs on the face-plate *A*. These studs allow the die case to center itself so as to cut the correct size.

The special use for the rig in this case was for making a lot of false teeth for the dental job shown in Fig. 2. This was a large cast-iron pinion, whose teeth had been extracted without gas, and which was needed at the earliest possible moment, until a new one could be had from the maker of the machine.

So the roots were drilled out and tapped for ¾-inch studs. The rod *D* was run through the die as far as possible, and the end sawed off. Then a nut sawed on one side was clamped in a dog, as shown, and used to handle the rod in screwing it through the die, and into the pinion to be cut off the right length for each tooth. A file finished them accurate enough for the few days they were to run.

It would have made a better job to use a larger stud and to cut the thread only on the portion going in the pinion; but for this temporary job the method shown was the quickest and also shows an application of the tool-holder which makes clear its usefulness.

In cutting bolts of this kind it saves dragging the carriage and secures a thread that is more nearly the same pitch as the die.

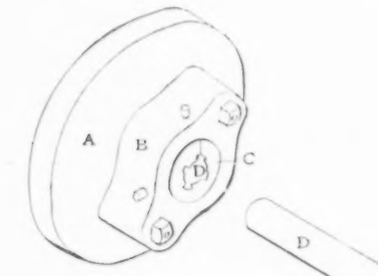


FIG. 1

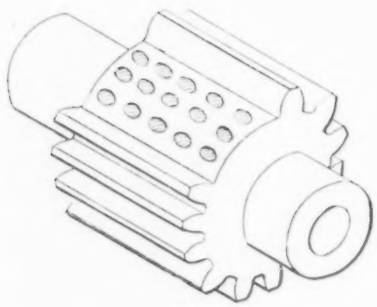


FIG. 2

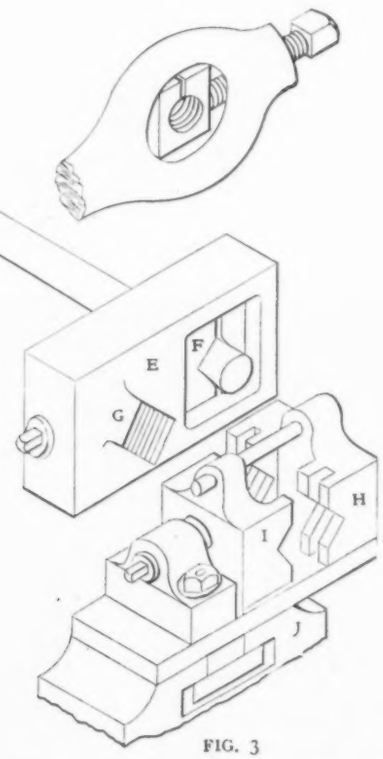


FIG. 3

A BORING-BAR HOLDER AND A BOLT-CUTTING JOB

Sammy's Shop—Starting the New Place and Getting a Foreman

The location which Sammy found for his new shop was much larger than the one where the other shop had been. It had some buildings on it that could be fitted up without much trouble so that they would do for a time. Among the institutions of this place were several building and loan associations. Sammy, in consideration of the fact that he was going to make improvements in the property, was able to borrow from one of them enough to pay for the property, and found that his monthly payments were not very much more than the amount he had been paying before as rent.

A Foundry and Blacksmith Shop are Started

His former experiences had shown him many things, and besides getting machinery for the shop he made a cupola from an old boiler shell with a stack built on; and when he got it set up and lined, and got a brass furnace built in the corner he was ready to start a foundry. An anvil, a couple of sledges, and a few tongs and other tools made a start toward a blacksmith shop, for it was easy to build a forge and the same fan that furnished wind for the cupola also furnished it for the blacksmith's fire. Even if it was rather large for that one fire through the day, and so small when the foundry was taking off a heat that the blacksmith had to be careful or there would be trouble for both departments, yet it did for a time.

These things did not come all at once. He got the shop going first, then he got the brass furnace built and going. He felt the need of it very much, as he had to send out of town for all of his brass castings. He could get iron castings there, but believed that he could make them cheaper than he could buy them. The blacksmith shop in a small way had been part of the old shop, but here he located it in a place where he could expand if there should be any need of it.

A Temporary Foreman

Most of the men who had worked for him in the old shop were with him again, and among them was Albert. As Sammy had to spend some of his time with whatever part of the establishment needed it most, he was often absent from the machine shop, and it was his custom to have Albert "look after things" there. This went on so much that he was gradually looked on as a foreman by the men, without there being any definite arrangement to that effect. He was a good work-

man, and had a natural insight into the combinations of machinery, but he was not good at giving orders and then seeing that they were obeyed; and then, he lacked education. Sammy understood this and had often thought over the necessity of having a regular foreman, but did not know where to get the kind of a man that he did want, and Albert seemed to be the best material at hand and was much better than not having anybody to help keep things going.

The Boy Who Wanted to Know

Among the boys who from time to time worked in the shop was one Fred. Fred had worked for some time in another shop and was "handy." He was so inquisitive that the men used to have lots of fun trying to "stuff him." If a new sort of job came in the man who was working on it was quite sure to be visited by Fred during the noon hour, and he was indeed a "grouch" if Fred was not able to pump some information about it from him—either that, or else the man did not have any to give. The lad was keen enough to know that the men often tried to mislead him, and unless he could see that the statements made were reasonable from his view point he would insist on the reasons, which often started arguments among the men as to the reasons for things.

Good Qualities

The men all liked him, for he was always willing to help on any sort of a job and to stay with it and them until the job was done, and they soon found that it was safe to leave many of the details to him. As time went by they began to come to him for information, for he had not been satisfied with the information that he could gather from the men but was a great reader of mechanical papers and books. He was not satisfied to know how to set the valve of a steam engine to have the engine run. He wanted to know *why* it had to be set so. Everybody knew that Albert could "work all around him," but he wanted to know *why* this was so. Along with learning to temper his tools he was puzzling his head in finding out *why* steel hardened. He was alert and a good writer, and Albert used to send him forward to meet customers that came in when Sammy was not there.

Bashful Customers

There is one peculiarity about the customers who come to a jobbing shop. Even where there is an office and a man in it very few of them will go there. If need be they will go around and come in the back way to avoid it. Whether this comes from experience or instinct I cannot say, but unless the man who does the work is also the office man, or else there is no other possible way of getting into the works, most of them will dodge the office when wanting work done. Fred felt the same interest in getting information from a customer that he did in doing any other job; and if the man who did the job wanted information which he could not supply he was as much ashamed as he would have been of doing a poor job of machine work.

A New Foreman Suggested

No job was too intricate for Albert, but looking after the men had always been distasteful to him, and one day he kicked over the traces and notified Sammy that unless someone else had that to do he would quit. Sammy urged his need of someone in that capacity part of the time, and Albert pointed out the qualifications of Fred. That was a new idea to Sammy. He valued Fred, but had never thought of him in that light before. Why, he was young; but when that was thought over he was quite a bit past 21. He was young at the business, for a fellow who has been less than five years at the business cannot lay much claim to being a veteran, but to offset that, he was a most persistent digger after information and knew more about some things than some people will ever know, no matter how long they keep at the business. The upshot of it was that Fred was called to one side and sounded as to his ideas on the subject. It did not take long for Sammy to find that he had ideas, and they all centered around one point.

The Position is Filled

He did not even mention the matter of wages or the duties that would be part of the new arrangement, but he did want to know definitely what the extent of his responsibility and his authority would be.

"If you only want me for an errand boy to carry the orders to the men, and for a kind of a spy to report to you, I don't want the job; but if you want me to be responsible for the work when you are not here, I must be able to manage in the best way I know how, and to do that I must have the authority and the men must know it, and understand that what I say goes just the same as if you said it. If that is the way it is to be, I am willing to try it," was the way he put it up to Sammy.

Sammy took several days to consider the matter and finally came to an understanding, more because he had to have someone to help him than because he was perfectly satisfied. He did not know where such an arrangement might lead to. A notice was posted, the substance of which was as follows:

Notice: Mr. Fred ——— has been appointed foreman to act until further notice. His orders are to be followed the same as though they were given by me.

Signed, Sammy ———.

The New Foreman Not a Straw Boss

Most of the men received this without comment, but some of them thought it a great joke, and one of them thought to try how far he could go with "the brand new straw boss," as he called him behind his back. Many of the men were rough spoken and Fred did not mind it in the least as far as any outward sign would indicate; but this man refused to do a job the way Fred directed him to do it.

"Sonny, I worked in a machine shop before you were born. You can't learn me anything," said he, with a contemptuous laugh.

"You are getting paid for working here. If you do not care to do the work as we want it done you cannot work here. That is all there is to it now." Fred looked him squarely in the face.

"Why, you ———," no need to repeat that outburst. Most of us who have worked long in a shop know how they sound, and those who do not would not be benefited if they had the knowledge.

"If I am to understand from that that you are not willing to do the best you know in carrying out every order you receive, you are out of a job, and your time stops right now." To save misunderstandings Fred had been writing out the orders he gave to the men, and he now reached up and took the disputed order from the hook, looked up at the clock, and made a note of the time, and then walked away.

The Workman Backs Down

This was not exactly what the man had expected. The job was a good one, and he did not want to lose it. In reality he was not a bad man, but he had been used to working under rather slack discipline. After thinking it over for a few minutes, he went over to Fred.

"See here now, young fellow, there is no use of you rearing up and getting on your high horse just because a fellow tries to have a little fun with you, or wants to give you the benefit of his experience. We don't none of us know it all. If you feel so bad about it, of course, I will do that job any way you say. It don't make no difference to me. Hain't it all right now?"

"It's all right if you follow your orders. I am thankful for any suggestions or information the men give me, but until I change an order it must be followed, and the quicker that is understood the better."

The Foreman Gives His Own Orders

Sammy heard of this some time after, and feared that he might have trouble, but found that there was only one point where Fred was hard in the bit. He was willing to have a job done in any way Sammy wished, with any men he wished, and in any order he wished; but when he gave an order he did not allow it to be changed when he was there, except through himself. If Sammy went to him there was no trouble, and Sammy had to admit that Fred was right in this, and

he had to also admit that the shop looked more orderly and that the work was coming out in better shape than it had been doing since he got started up.

As soon as the men found that he was willing to take the responsibility when his orders were carried out, they were satisfied with the new foreman, and as Sammy had lots to keep him busy in trying to get good castings out of his small foundry and make money doing it, the details of the machine shop were more and more thrown into his hands.

Home-made Gages

Sizes in a job shop are apt to vary according to the means at hand to correctly measure them, and the skill of the man doing the job. Fred used pieces of cold-rolled shafting about a foot long for standards for many sizes, and forged up some pieces and made snap gages which he fitted to these shafts. These were the first shop standards and the men were required to work to them. Later, when micrometers got to be available, these sizes were found to be not strictly accurate, but they were much more so than the sizes as usually taken from a mixed variety of old and new scales and rules by good, bad and indifferent workmen, and saved all disputes as to whose scale was the nearest right, and as to who got nearest to the right place on that scale with his calipers. If a size was wanted for which he could not readily get a piece of cold-rolled shafting, he would have Albert turn up a piece to as accurate a size as he could. This piece was stamped on the end and became the standard for that size.

Shop Requisitions

This new shop was large enough to require a man in the office. After several disputes with this man as to the orders received, Fred insisted that all orders coming from the office to the shop must be in writing to make him responsible, and that he must give all directions for supplies and materials in writing, and unless the wording of his requisitions was followed in sending in the orders, he would not be responsible if the material came wrong. It took some warm arguments and costly mistakes to show that this last was a necessity, and to convince the office man that it was as risky to change the wording of a shop requisition as it is to change the legal phraseology of a deed. While admitting that the material might not be as desired, he was slow to comprehend that the use of what looked to him like poor English would be any more apt to get it right than the form which he had used. W. Osborne.

Making Pulleys for Electric-cab Brakes

Manufacturing methods and job shops mighty seldom go hand-in-hand, but a close approach to it was found the other day in the shop of Campbell & Co., who do general repairing of all kinds. The equipment is limited, and ingenuity increases under such conditions.

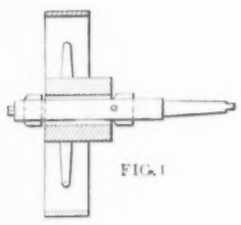


FIG. 1

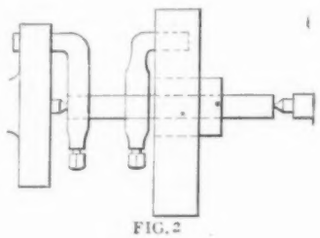


FIG. 2

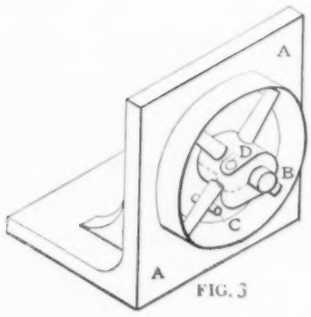


FIG. 3

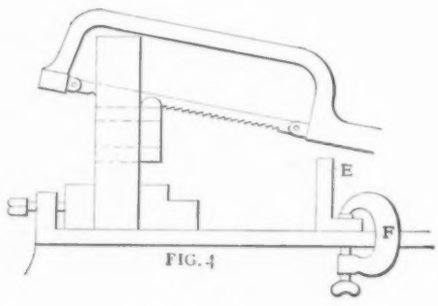


FIG. 4

MAKING PULLEYS FOR ELECTRIC-CAB BRAKES

The job in question was a hundred or so cast-iron wheels or pulleys for braking on electric cabs. These are about 9 inches in diameter, 2½ inch face and 1¼ inch bore through the hub, which must be split as shown, so as to clamp on the shaft.

These pulleys are first chucked for boring, and the hub faced in the lathe. The boring bar fits the taper of the tail spindle, and carries two cutters, the first to rough, the second to finish. They are far enough apart so that the roughing cutter passes clear of the hole before the finishing cutter starts to work. These are simply flat cutters mortised through the bar, the first held by a set-screw in front, the second keyed or pinned in place. See Fig. 1. In pinning a cutter of this kind, always put the pin in front so as to hold the cutter back against the bar. This takes less pressure on the cutter, and is less apt to split it, as well as holding it more firmly.

To insure an even feed to this boring bar, the tailstock is strapped to the carriage so as to be fed by it, the tailstock sliding on the ways during the boring. The time for chucking, facing the hub, boring, and removing from the chuck is nine minutes each.

A mandrel, which is turned to a good sliding fit, is used for turning the pulley, the driving being done by a stud between the spokes. Or a bent-tailed dog can be fastened to the mandrel, between the pulley and the dog which drives the mandrel, so that the tail will stick between the spokes and drive the pulley, as in Fig. 2. It can be fastened to the dog or a collar slipped on the mandrel to hold it. The facing and turning of the rim is plain sailing, and the only way of saving time is to make as few changes of tools as possible. So, on the first pulley the facing is done first, and the turning last; on the next this is reversed, as the turning tool is still in the lathe. A little later they intend putting on a second tool post at the back, and using a straddle tool in that for facing both sides of the rim at once, and turning the face with the front tool, to save the time of changing tools.

The drilling jig (perhaps "rig" would be better) is simplicity itself. The angle plate *A* has a stud *B* on which the bore of the pulley is a neat sliding fit. It also has a stud *C* so located as to catch a spoke when the boss *D*, on the hub, comes level with the table, to be drilled. The angle iron is located so as to bring the drill in the right place on the hub, the table is clamped on the column, and putting them on the stud locates the center.

A 3/8-inch drill is used first, being marked so as to drill a little over halfway through. All are drilled in this way first, then the smaller drill for the tap goes through the lower half of the hub. Tapping is also done in this drill press.

Splitting the hub is all that remains to be done, and what might be a mean job becomes an easy one by the use of a power hack saw, as shown in Fig. 4. The pulley is clamped in the vise with the lug of the hub up. The blade is put through, as shown. The only change is to throw out the trip which lifts the saw, and which would be apt to break it. In its place the angle iron *E* is fastened to the table by the clamp *F*, and prevents the saw cutting into the lower part of the hub.

These simple appliances and methods result in very rapid work for a general repair shop, and the results are as accurate as the work demands.

Machining Time-recorder Frames

Description of the Profiling and Milling Fixtures Used and Details of Setting, Supporting and Clamping the Work

BY EDWARD SNYDER

Fig. 1 shows five views of the right-hand frame of the card recorder made by the International Time Recording Company of Binghamton, N. Y., the tools for machining which were designed by me. The frame for the left-hand side of the machine is quite similar to the one shown and need not be illustrated. These frames are gray-iron castings, are about 9½ inches high and 7 inches from front to back. The arms of the right-hand frames are about 3 inches high; those for the other frame are about 3½ inches high. The castings are about ⅛ inch thick and ribbed, as the different views show.

The three feet of each frame are made heavy so as to withstand the jar of shipment without danger of breaking. The two lower feet of each frame are made fast to the bottom and the upper one to the back of the wood case which incloses the clock movement and recording mechanism.

The casting in Fig. 1 is designated by the characters *H.3.1* cast on the outside near the base, and all the tools used for manufacturing this frame have these characters either cast or stamped on them, and also the purpose for which the tool is used. The tools for the left-side frame, *H.4.2*, are likewise designated.

When a lot of these frames are being carried through, they are first checked out from the storage bins, then the burs and lumps are removed by grinding and filing. The frames are next given a coat of black japan, it being permissible to apply it by dipping at this time, whereas if it was done after they were machined it would have to be applied with a brush.

The First Machine Operation

The first machine operation on the frame is done in a two-spindle profiler, one cutter finishing the bosses and the other being used on the feet. During all subsequent operations the gaging is done from the face of the bosses and the three feet, where machined.

Fig. 2 shows four views of the profiling fixture, for *H.3.1*. As the fixture for the other frame is practically the same, except for being the other hand, it need not be described.

The surfaces at *A*, *A'* and *A"* on the frame gage against the round head stops at *a*, *a'* and *a"* on the fixture. By a slight adjustment of the stop *a* in or out, as may be required, the edge of the frame at *B* is made to bear against the stop *b* on the fixture.

Setting the Work

When placing the frame in the fixture for profiling, it is noted whether the outer ends of the top and bottom arms at *C* and *C'* bear the correct relation to the two sheet-steel gaging forms at *c* and *c'* on the fixture; when the frame is correctly located there should be about 1/32-inch space between the edges of the gages and the casting. It is permissible to let the frame touch the gages, as it has been ascertained by repeated trials that if the two arms at *C* and *C'* are no farther away from their correct location than the gages will permit, the other parts of the frame will finish correctly.

The downward pressure on the frames is sustained by three plugs *d*, *d'*, and *d"*, directly beneath the three clamps *e*, *e'*, and *e"*. These plugs bear on the frame at *D*, *D'*, and *D"*.

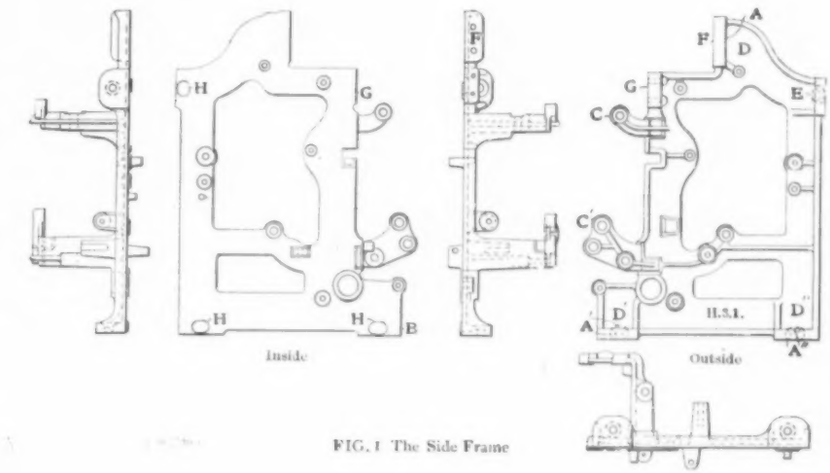


FIG. 1 The Side Frame

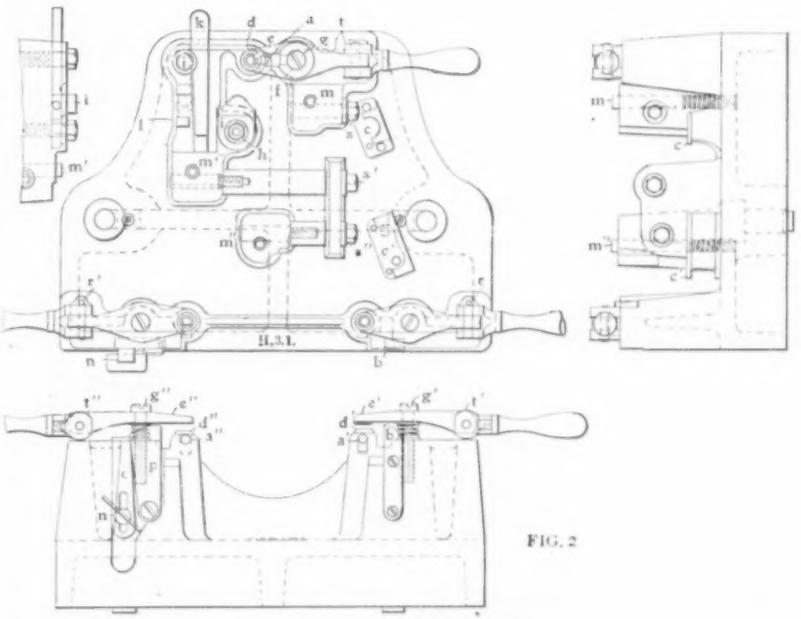


FIG. 2

THE WORK AND THE PROFILING FIXTURE

The Clamping Devices

The clamp *e* can be removed by taking the slotted washer *f* from under the head of the screw *g*. Clamps *e'* and *e"* are given about a quarter turn, screw *h* is loosened and clamp *i* is pushed back, screw *j* is loosened and key *k* is moved

outward, allowing plunger *l* to move a short distance toward the center of the fixture.

The spring plungers *m*, *m'*, and *m''* are next pushed back, the screw *n* is loosened, and the wedge *o* drops, allowing the stop *p* to swing back. The fixture is now prepared to receive the frame.

Securing the Frame in Place

After observing that the frame bears against stop *b* and the lower ends of its arms at *C* and *C'* clear the templet gages, wedge *o* is raised, causing *p* to hold the frame against stop *b;* clamp *e* is replaced and clamps *e'* and *e''* are turned to their proper positions against the stop pins *r* and *r'*. The clamps are now given a slight tension; next key *k* is slid in, thereby forcing plunger *l* against the inside of the top foot of the frame at *E*. Screw *j* holds the key in place and has a tendency to force the key in when it is tightened. Clamp, or stop, *i* is pushed against the inside of the frame and made secure by means of its screw. Clamps *e*, *e'* and *e''* are now tightened securely. Then the nuts *s*, *s'*, and *s''* are slacked and tapped lightly to allow the plungers *m*, *m'* and *m''* to be lifted by the coil springs beneath. The nuts are now tightened and the profiling proceeded with. The springs under the plungers are not very stiff, for while one alone might not spring a frame the three would if they were adjusted to a stiff tension.

The Spring Plungers

The construction of these plungers and the means of binding them may be easily seen. All parts are of tool steel and hardened, and although at first sight it may not be thought a good idea to have one hardened piece bind against another likewise hardened, trial has demonstrated that the force exerted by the screw and wedge action is so powerful that if one were soft it would crush and swell out and become jammed in the hole. I would caution anyone who tries this device to be very liberal with the metal that he places around the plunger and wedge.

These plungers will not force back even under the abuse of a violent chattering cut, and will stand without becoming loose where a set screw and lock nut would not do at all. Also, they can be placed in under a casting or fixture where a screw and lock would not be accessible.

Construction Details

The clamps *e*, *e'*, and *e''* are of tool steel hardened and drawn to a spring temper at the cam end; the three cam portions *t*, *t'* and *t''* are of tool steel hardened and are pivoted on 5/16-inch drill rod pins. The handles are of machine steel threaded into the cams. Clamp *i*, like the various stops and bearing points, is of tool steel and hardened at the end that bears against the frame. Plug *l* has a small pin fast in the top, having a movement in the slot as indicated; the pin is to prevent *l* from turning, the end next the key being beveled to the corresponding taper. It will be noticed that all the nuts requiring a wrench are the same size, consequently but one wrench is used and a long handled socket wrench has been found to be the most convenient. Stops *b* and *p* serve also as gages for the thickness to which the bottom feet are machined. A tool-steel piece not on the drawing, near screw *j*, also serves as a gage by which to set the cutter when finishing the upper or back foot.

Second Operation Fixture

The next operation on the frames is to mill the surfaces at *F* and *G*.

Fig. 3 shows the fixture on the milling-machine table with clamps and cutters in position as though a frame were in place and being milled. The arbor and fixture were designed so as to bring the work as near to the column of the machine as possible.

The fixture is located by means of the two tongues on the bottom and held in place by four bolts. The depth of the cut is gaged by hardened steel blocks not indicated on the drawing.

Before placing a frame in position to be milled the three cam handles *a*, *a'*, and *a''* are turned, allowing the clamp to be lifted by the springs beneath. The outer ends of the clamps are supported by studs *b*, *b'*, and *b''* which are necked to fit in the slots at *c*, *c'*, and *c''*. When the cam handles are released the clamps *d*, *d'*, and *d''* are slid out as far as the slots will permit.

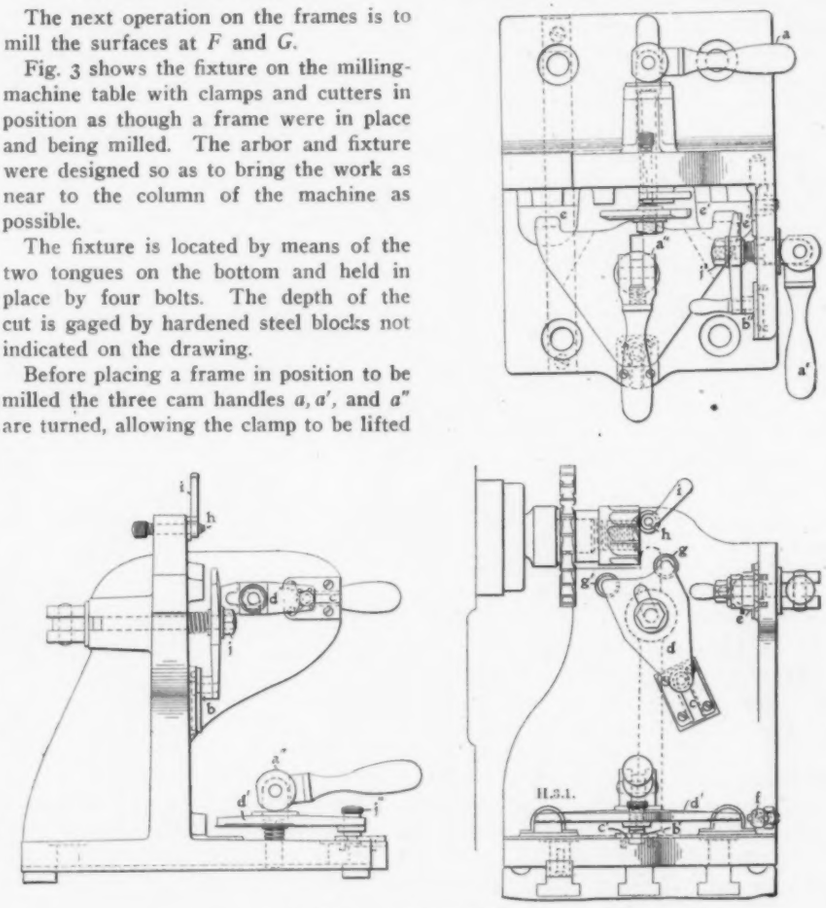


FIG. 3. MILLING FIXTURE

Supports for the Work

A frame is now placed in position, the profiled surfaces of the two lower feet resting on the spots *e* and *e'*, the upper foot gaging against the surface *e''*. The screw with lock nut at *f* is not intended as a gaging point; it was placed there as a matter of precaution to prevent any error due to carelessness in clamping. The bosses *H* on the frame (Fig. 1), adjacent to the three feet, rest against three spots square with the surfaces *e*, *e'*, and *e''*, the only other points at which the frame bears on the fixture being the two bosses at *g* and *g'* and the small screw *h*, it being necessary to have an adjustment here as the screw does not bear against a profiled surface. This screw is locked in position by means of the tapped handle *i*. When this handle is released it is prevented from dropping to an inconvenient position, by the small pin on the upper side.

Clamping

With the frame in position the clamp *d'* is moved forward and clamped, then *d* and *d''* are simultaneously slid into position and clamped. Should the clamps not bind hard enough, or too hard because of variation in the thickness of the feet, the proper pressure is obtained by means of the nuts *j* and *j'* and nurled screw *j''*. The screw *h* is adjusted and locked while the cutters are starting the cut.

The end mills used on this job are hardened only about half way, and from 1000 to 1500 frames have been milled without the necessity of regrinding.

Following the milling operations the frames are placed in a conveniently handled lid jig where the various holes are readily drilled, and then they are held in another handy jig while tapping, facing, countersinking, and reaming certain of these holes.

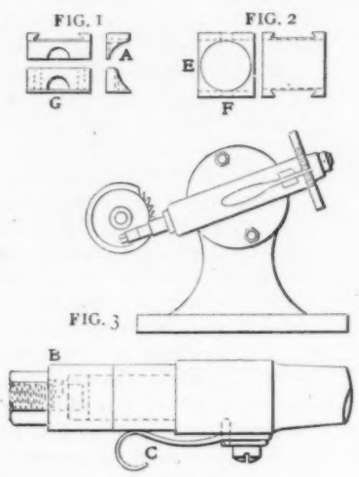
Machining Rifle-sight Tips

By B. Norton

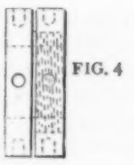
[The illustrations referred to in this article having been omitted from page 394, this volume, the article is reproduced. Ed.]

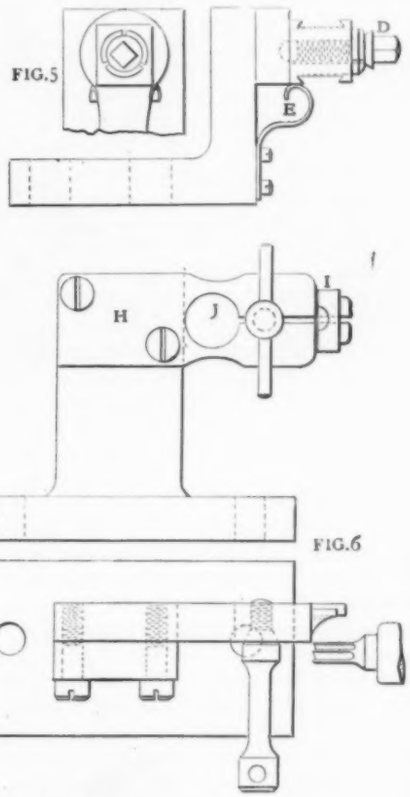
A completed sight tip as used on the Lee-Metford and other pattern small arms for the insertion of the back V sight is shown in Fig. 1. There is usually an increased demand for this attachment about the time of the Bisley Summer competitions, bad and doubtful sighting often being corrected by the removing and replacing of back-sight tips with new ones which are trued to the competitor's instructions upon the spot.

A sample and quantity having been submitted for quotation, this was duly brought into the machine shop. It was suggested from the office that strips (the material being malleable iron) should be cast sufficiently long to cut up into eight or ten tip pieces, arranged end to end. The suggestion, however, presented several difficulties, not the least of which was the extreme awkwardness of holding, also the number of operations, and consequently tools, fixtures, etc., required. In addition, under attendant conditions these tools would necessarily have been expensive to construct.



Machining Rifle Sights





MACHINING RIFLE SIGHTS

Making Four at Once

After due consideration I decided that by taking advantage of the radius at *A*, Fig. 1, I could arrange four of the finished pieces in such a manner as to form sections of a circle, of which these were arcs. This arrangement left just sufficient margin between them for cutting through, as shown by the dotted lines in Fig. 2. Moreover, the resulting piece being square outside and circular inside, lent itself very readily to holding while being machined, and brought the cost of the cutter and fixture work down to about 40 per cent. of what would have been required to work the strip castings. There was also every possibility of obtaining a good finish, which seemed very remote under the conditions first suggested.

The Tools Used

Commencing with the cored hole a roughing, and afterward a finishing reamer give a nice bore of a uniform size, this being absolutely necessary as a foundation for subsequent operations. A facing cutter with pilot to fit the hole next trimmed up the two ends, being stopped to correct gage for length.

The four remaining sides were squared up in the milling machine with three straddle cutters. These were arranged upon milling as shown in Fig. 3. The bored and faced casting was slipped on to the arbor in the inclined index head, locked up with a nut and collar, this collar having a small featherway which engages the peg at *B* to prevent movement when the nut is locked up, Fig. 3. The slide, running parallel with the spindle axis, was stopped between two suitable points and the work was fed into the spacing between the cutters. A good plan to obtain a definite gage between cutters so arranged is to make up screwed collars, as shown in Fig. 4, with three or four holes around for pin adjustment; the troubles with a solid collar usually experienced after regrinding or reversing the cutting faces will disappear altogether. Locating the work for this squaring operation is by swiveling the flat spring *C* which is brought into position when pieces are slipped on the arbor and afterward moved away for cutting. A quarter of a turn of the index plate gives alternate positions for feeding between cutters.

The dovetailing came next. This, it will be noticed, is across or opposite the hole. A vertical milling machine being available, it was decided upon as being most convenient to use for this operation. Fig. 5 shows the simple, but effective means of holding; *D* is an arbor having three slits and expanded by the cone pin. The cutter was made of such a size that one cut only was needed. *E* is the flat spring to which pieces automatically accommodate themselves when fixed as in the previous operation.

Separating the Pieces

The cutting apart of the four tips followed next. This was accomplished with work again placed on the arbor in the head, Fig. 3. Under similar conditions to the squaring operation, but with two saws equal to the width of the spaces indicated by dotted lines at *E* and *F*, Fig. 1, holding, indexing and stopping were identical. There was at the outset a doubt as to whether the pieces would remain in position upon the arbor after being severed by saws, which, of course, happens when one has made the first two cuts; there was, however, in practice no difficulty experienced in this respect, providing that all faces were kept clean and freed from cuttings after each removal.

The last operation was the radius in which the V is cut when sighting, shown at *G*, Fig. 1. The dovetail is made use of for holding in this case, Fig. 6 being the machine fixture. The steel plate *H*, dovetailed at the end to receive the tip *I*, is cut through into the hole *J* as shown, this being made large so that the expansion screw need not be screwed up too tightly for fear of distorting the tips. A plain end-milling cutter run at a fairly high speed and kept sharp was used in this last instance. It may be interesting to add that a plentiful supply of suds was used throughout, and the finish was all that could be desired.

The first train was run over Morocco's first steam railroad on December 15. The line was built by the German Harbor Construction Company. It is narrow gage and a mile and a quarter long.

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To Our Canadian Subscribers

The present postal treaty between Canada and the United States expires on May 7 next. The Canadian Government has before it a proposition to increase the rate of postage on periodicals from the United States to such an extent as will make it necessary for us to about double our subscription rate to Canada.

If Canadian friends of this paper object to such a raise it would be well if they wrote their postal authorities protesting against such action.

The Young Technical Graduate

Much has been said and written about the young technical graduate, from the manufacturers' standpoint; and his shortcomings, which have been held to reflect the shortcomings of the schools, have been enlarged upon at length. Very little indeed has, however, been said from the graduates' standpoint, and it may be worth while to put one's self in his place for a few minutes.

It has come to be pretty generally understood that in spite of the graduate's shortcomings on graduation, he eventually makes good, the period of his probation being, apparently, about two years. In his address at the opening of the new engineering building at the University of Pennsylvania, Fred W. Taylor referred to these two years of probation as years of discouragement and disappointment to the graduate, and a few more words on this topic will not be out of place.

The average age at graduation from our technical schools is, we suppose, not far from 22 or 23. With the high requirements for admission which are now exacted by these schools, it follows that, in practically all cases, the graduate throughout his entire life hitherto has done nothing but attend school. Amid the blare of trumpets, this comes to an abrupt end on commencement day, and the graduate finds himself pitchforked into new surroundings, in which the first concern of everyone is not to learn lessons and to pass examinations, but to earn a living. It is not surprising that on this new deck of action he staggers a little, and that it takes him a little while to find his sea legs. There could not be a more complete change of environment, nor one more calculated to test the fiber of the man. He does not deserve ridicule, and he should not have it; but, on the other hand, he deserves and needs a little encouragement, and the pressure of the right hand of fellowship.

The wise man in this world loses no legitimate opportunity to make friends, and the graduate's necessity is the other man's opportunity. There is no cement for friendship like the feeling of gratitude, and the man who will give the fledgling engineer to understand that earning a living is a task at which not many fail, and that the world is not nearly so big as it looks to him, and thus supply a little stiffening for the backbone that needs it, will secure a friend who may sometime in the future be worth having.

A Magazine for the Blind

A periodical which has just made its appearance and which is called the *Matilda Ziegler Magazine for the Blind* will without doubt be welcomed by thousands of sightless individuals throughout the country. The new magazine will appear monthly and the cost to the reader will be merely nominal, 10 cents per year, though the expense to Mrs. Ziegler, who, because of her interest in the blind, is supporting the publication, will be not less than three dollars for each subscriber.

The magazine is about 16 or 18 inches square and 2 inches thick, hence it is probably the bulkiest periodical published, although it contains but fifty pages. Only one side of the page is utilized, the reading matter appearing in raised dots over the surface of the sheet. The point system of printing for the sightless makes use of characters formed by six dots arranged in different combinations for the letters of the alphabet, and the impressions in the sheets are made by means of a copper plate in which the characters are struck by a machine having a keyboard arranged much like that of a typewriter. The pages are first soaked in water and after printing must, of course, be dried with considerable care and without pressure.

It is stated that publishing houses and authors have granted permission to the proprietors of the magazine to reproduce freely such works as they care to publish, and they will therefore be able to put into the hands of the blind much of the best of the latest literature. The present issue contains, among other features, the first installment of a story which is to appear serially until completed, a department dealing with current events, various exercises and games for the blind and two or three illustrations, one of which is a map of the Kingston earthquake zone.

Of the first issue of the magazine, comprising some 7000 copies, nearly 5000 copies are being mailed to individuals in different parts of the United States, while the remainder will be sent to various schools and institutions for the blind.

Information Wanted

A French automobile factory wishes the address of American manufacturers of hydraulic presses for forging automobile axles in one or two operations. Address replies to this office.

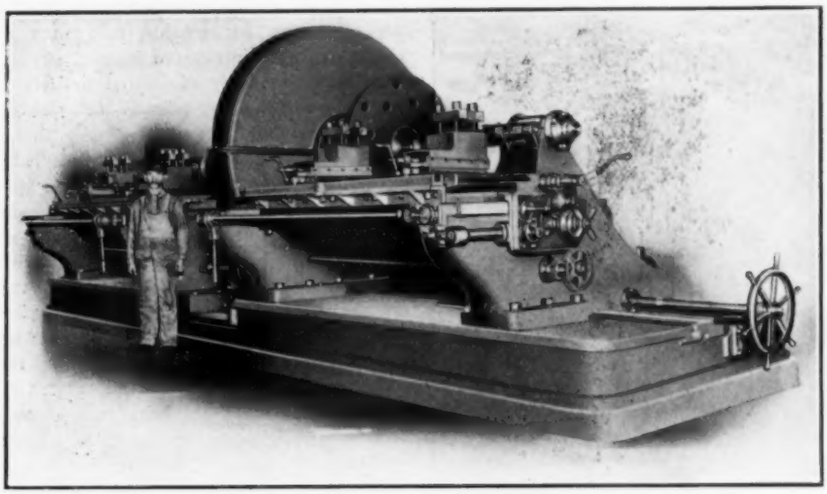
New Tools and Machine Shop Appliances

Showing the Progressive Development of Modern Shop Equipment and the Progress of Design in This Department of Work

THE LATEST INFORMATION

A Large Double-pulley Lathe

The illustration shows a lathe built to turn two pulleys, 96 inches diameter and 72 inches face, at the same time. These pulleys are cast in halves.



A DOUBLE PULLEY LATHE

After the pulley has been bored it is mounted on an arbor in the pulley machine. This arbor is a taper fit in the spindle of the lathe. The tail end of the arbor runs in a bronze bearing in the tail cap. Drivers are inserted in the holes in the face plate in a proper position to drive from the arms of the pulley. These face plates are of steel. The crown of the pulley is done with an automatic crowning attachment located at the front of the slide. This crowning attachment can be adjusted for different crowns, there being a roller in the compound slide which runs in a groove in the top of the crowning device. The slides are located in the front of the machine, thus leaving the back free to swing the pulleys into place. There are two tool rests for each pulley. The long slide or rail can be fed in for different diameters of pulleys by the hand ratchet lever shown in the front. When once adjusted for the proper diameter this slide or rail is clamped tight. The feeds for the tool rest are operated from the outside ends of the two rails. The cross feed is by hand. The longitudinal feeds are gear driven, thrown in and out by a friction, and are reversed by the hand lever shown on the apron. To facilitate getting the arbor in and out, the tail caps are hinged so they can be swung back out of place; there is also a step in the tail cap for taking up the end thrust. The tailstocks are adjusted by the pilot wheels shown at each end of the lathe.

The lathe is worm driven, the worm wheel being 96 inches pitch diameter. The worm is double threaded and the thrust is taken up by a ball thrust bearing. This worm runs in a bath of oil.

The motor which drives the lathe is 50 horse-power, and is geared to the worm shaft. A change of gearing is furnished which is operated by a lever. This lever operates a clutch which throws the different gears in and out. The feed is driven from a second worm which is located on the outboard end of the main worm shaft.

The main spindle in this machine is 14 inches diameter in the bearings. The machine weighs about 50 tons, and was built for the Jones & Laughlin Steel Company, of Pittsburg, by the Pittsburg Machine Tool Company, Pittsburg, Pennsylvania.

A Cinder Extractor

The illustration shows a handy little tool for extracting foreign bodies from the eye. The old-fashioned horse-hair loop is used, but it is securely held in a small nickeled tube having a cap to protect the horse-hair from injury. It is made by the Gem Cinder Extractor Company, Detroit, Mich.

A CINDER EXTRACTOR

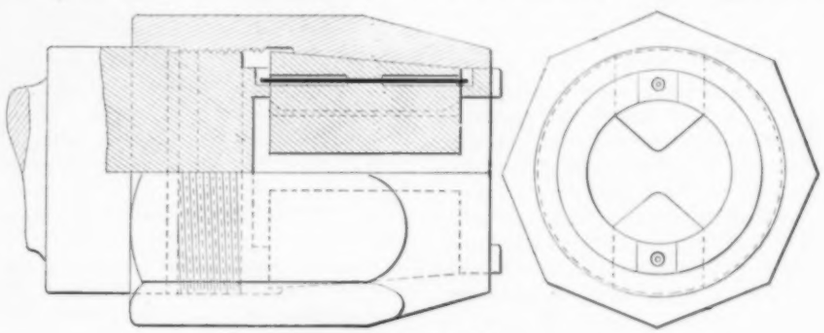
A Drill Chuck

This chuck is designed to hold and drive straight-shank drills which have two opposite longitudinal V grooves in the shank.

The hood of the chuck is threaded to the body. A concentric seat for the closing of the jaws is located between two straight bearings which fit the body, thereby holding the taper seat for the jaws true with the body. Revolving the hood to the right tightens, and to the left relieves, the same as in all ordinary chucks. The jaws when in position conform to the taper on the inside of the hood, making a true and rigid backing for the thrust put upon them.

The chuck permits considerable variation from exact standard sizes of drill shanks. The chucks are made in five sizes and regularly furnished with rough or taper shanks; or they can be fitted with any style and size of shank desired.

The capacity of the chucks ranges from 3/32 inch for the smallest to 2½ inches for the largest. Hoods for the three



THE DRILL CHUCK

smallest sizes are hexagonal in form, and for the two larger octagonal. These chucks are made by the Cleveland Twist Drill Company, Cleveland, Ohio.

A Wire Brush

The illustrations show a wire brush which is made in many forms for many purposes: flue brushes, boiler, scale and soot brushes, casting and machine-shop brushes, brushes to clean hot metal in rolling mills, file and brazing brushes,

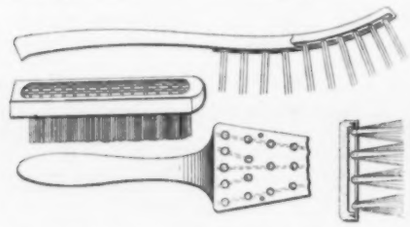


FIG. 1. CONSTRUCTION OF THE HAND BRUSH

brooms for wooden machine-shop floors and for sidewalks and concrete floors, track brooms, tree brushes, etc. The individual wires of this brush are bent in the shape of a hairpin, and pass through large holes in the body of the brush, and are kept from dropping out by wires on the inside which are threaded through the bent ends of the brush wires.

The object of this construction is to eliminate rigidity of wire, which prevents good contact with the surface to be brushed, and to avoid vibration and its ef-

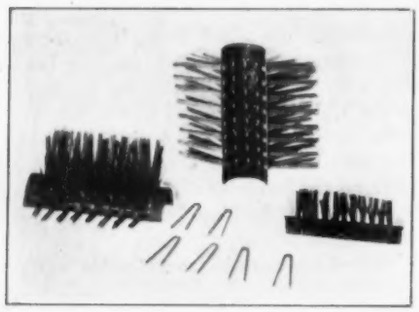


FIG. 2. CONSTRUCTION OF ROUND BRUSHES

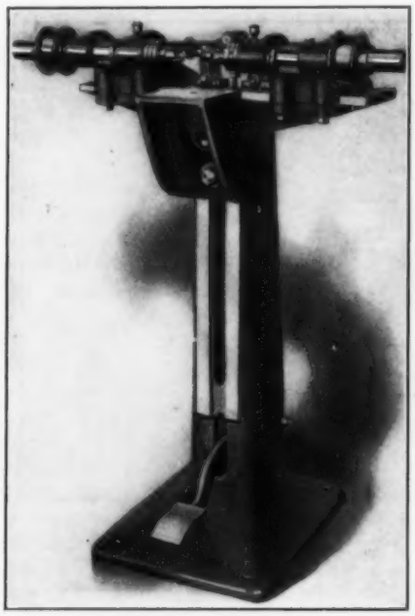
fect, viz., crystallization and snapping of the wire. A cavity is provided of varying depth in this brush into which the wires may recede somewhat when the brush is used, and especially when its stroke is reversed so that it will adapt itself better to the contour of the surface of the work. A brush is thus obtained with the effect of an elastic back, which has no inactive wires. These brushes are made by the American Wire Brush Company, 25 Broad street, New York.

A Double-spindle Riveting Machine

The illustration shows a double-spindle horizontal machine for riveting hinges, hardware specialties, chains, etc., where heads are to be formed on either end of the rivet simultaneously.

At page 731, Vol. 29, Part 1, we described the single-spindle vertical riveter, and illustrated the spinning rollers. The rivet heads are formed by a pair of rollers in the end of each spindle. The spindles are advanced toward each other by means of a toggle which is actuated by the foot lever. The heads which carry the spindle are adjustable along the bed so as to accommodate various lengths of work.

The output of the machine is limited only by the rapidity with which the work can be handled, as the spinning of the heads is performed almost instantly.



A DOUBLE-SPINDLE RIVETING MACHINE

These machines are built by the Grant Manufacturing and Machine Company, Bridgeport, Conn.

Looking after Belting in the Machine Shop

Although belting is receiving more attention than formerly in machine shops, it is looked upon as sort of a necessary evil in most places and only the large shops support the dignity of a "belt man" to see that the belts do their duty and are not abused.

The most complete belt system that has come to light is credited to the Santa Fé railroad shops at Topeka, Kan., where the belting cost had been about $1000 per month with 300 recorded failures and has been brought down to $275 per month with less than 60 failures to its credit.

While few shops will go into this in all the elaboration of card systems in use here, some of their practices ought to be found useful in many shops. When a new belt is put in service it is provided with a 6-inch "take-up" piece. As it stretches this is replaced by a 5-inch piece and this in turn by a 4-inch piece, and so on until it gets down to business and retains a constant length. This changing is made easy by the use of the Jackson belt lacer, with its wire loops and rawhide pins.

Splices are used for everything except the main joint, which might almost be called an expansion joint, the length of splice recommended varying from 5 inches for a 1-inch belt to 9 inches for an 8-inch belt, and a splice the same length as the belt is wide for sizes above this up to 18 inches. An old letter press makes an excellent belt press. Any patternmakers' glue that is good is used.

Pulleys, especially cone pulleys, are made 25 per cent. wider than the belts and the allowance for tension is 1 inch in every 10 feet of measured length, using a steel tape. This is calculated to give a tension of about 100 pounds per inch of width for double belt.

They advise against using double belts on pulleys smaller than 6 inches and also against resin or belt dope of various kinds, advocating a mixture of equal parts of fish oil and tallow, applied hot, either with a brush or by dipping in a tank. Any grease that hardens is wiped off, to prevent slipping. This mixture is claimed to make belts pull better than any they have ever tried. New belts are all treated in this way and also old belts that become dry or glossy in service, especially those running in smoke or gas, as in a blacksmith shop. Gasolene is advocated for cleaning belts.

They should be relieved of tension whenever possible if they are to be left for any length of time, as this prevents stretch and the consequent taking up. Idlers should be raised and belts run off of cones at night or over Sundays or holidays.

Some of these suggestions may find a place in almost any shop and are worth thinking over at least.

Orson Desaix Munn

Orson D. Munn, who died of paralysis, February 28, in his eighty-third year, was the last of the two original founders of the firm of Munn & Co., publishers of the *Scientific American*, to which journal he had devoted his entire attention for the past 62 years. Mr. Munn was born in Munson, Mass., and was educated at Munson Academy. After a brief business experience in that town he formed a partnership with the late Alfred Ely Beach, who was at that time employed on his father's paper, the *New York Sun*, and in 1846 the two young men engaged in the business of publishing the *Scientific American*, an office being taken in the old *Sun* building, at the corner of Fulton and Nassau streets. Quite naturally, the editors of the journal were brought into touch with the inventors of that date, and

this intercourse led to the establishment of the patent department which is still maintained by the paper. Mr. Munn was a member of various city clubs and historical societies. His former partner, Mr. Beach, died about eleven years ago.

New Publications

BULLETIN OF THE ENGINEERING EXPERIMENT STATION OF THE UNIVERSITY OF ILLINOIS, Vol. 1. Urbana, Ill.

This volume collects together the eight bulletins already issued, which have been noted in our columns from time to time, and extensive extracts given from some of them. The tests so far made include concrete beams, high-speed steel, drainage of earth roads, resistance of tubes to collapse, holding power of railroad spikes, and fuel tests with Illinois coal. The work of the experiment station reflects great credit upon the University of Illinois, and from it many other institutions of learning might take useful hints for the utilization of their laboratory facilities.

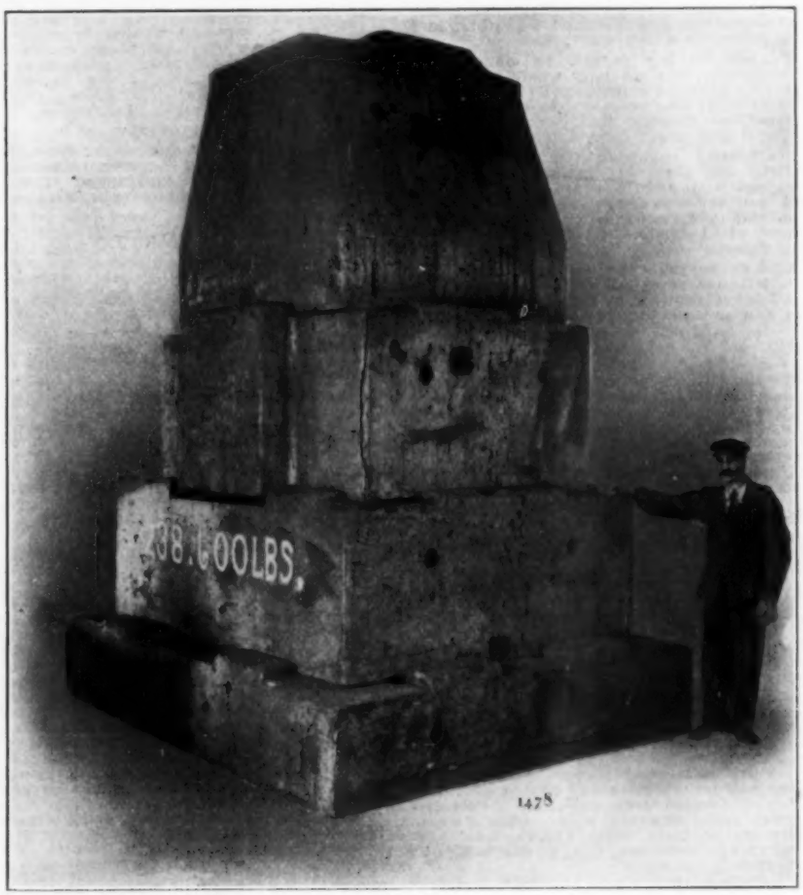
ENGINEERS' AND GENERAL SMITHS' WORK. By Thomas Moore. 248 5x7-inch pages, with 401 illustrations. E. & F. N. Spon, London; Spon & Chamberlain, New York. Price, $2.

Very few books have been written on the art of the blacksmith, and the author of this book, who is a practical smith, has endeavored to put some of his experiences on paper in order to assist others. The book relates almost entirely to hand forging over the anvil, and is filled with helpful illustrations showing the methods of doing a great variety of work. Chapters are included on the materials used by the smith, and on the testing of materials. The book impresses us as one which no young smith can afford to be without, and as one from which many an older one will obtain many useful hints.

MODERN AMERICAN MACHINE TOOLS. By Prof. C. H. Benjamin. 317 pages, 5½x8½ inches; 134 illustrations. E. P. Dutton & Co., New York.

Although the author states that the object of this book is to show the buyers and users the prominent characteristics of modern machine tools as now manufactured in the United States, instead of describing the details of the operation for the mechanics who will run them, we believe he has made a book which will be extremely interesting to all mechanics who wish to be informed on these lines, and that they will appreciate the points he has brought out. He takes up in turn the planing machines of various kinds, which include crank planers, shapers, and key-seating machines; engine lathes; special lathes, including turret lathes; boring mills, both vertical and horizontal; drilling machinery of various kinds; milling machines; gear cutters; grinding machinery; punching and shearing machinery, and improved screw-cutting machinery of the various types.

The illustrations, with the exception of a few details, are in half-tone and show the entire machines so that the relation of the various parts is clearly seen. It includes some of the most modern machines on the American market, and gives a large amount of data regarding cutting speeds and power required to operate the various tools. The practical shop experience of the author before he became a professor in mechanics enables him to bring out many practical points which might be overlooked by anyone less fortunate in this respect.



ANVIL FOR 24,000-POUND BEMENT STEAM HAMMER, WEIGHT 238,600 POUNDS

Personal

W. S. Morehouse has recently resigned his position with the A. S. Cameron Steam Pump Works, foot of East Twenty-third street, New York City, to accept the position of works manager with the Green Fuel Economizer Company, Matteawan, New York. He is a graduate of the Worcester Polytechnic Institute, a member of the American Society of Mechanical Engineers, and of the American Foundrymen's Association.

Obituary

Joseph B. Westbrook, founder and president of the Westbrook Elevator Company, Danville, Va., died February 6.

Rudolphus W. Fuller, inventor of machinery for making horse shoes, died at Hanover, Conn., March 11, 85 years old.

Mahlon Hoagland, Sr., founder of the machine and foundry business of M. Hoagland Sons Company, Rockaway, N. Y., died at that place March 7, 90 years old.

Walter Pierrepont Bigelow, vice-president and New York manager of the Bigelow Boiler Company, of New Haven, died of heart disease at his home, in New York City, March 7. Mr. Bigelow was a son of the late ex-Governor Hobart P. Bigelow, of Connecticut. He was born in 1866, and was graduated from Yale in 1887.

William H. Hoffman, for many years a consulting engineer in New York City, died recently of heart disease at Newton Highlands, Mass., aged 70 years. Mr. Hoffman was born in East Hartford, Conn. He entered the shops of Woodruff & Beach at Hartford in 1854, where he worked until April, 1861, when he enlisted in the Union Army.

Shortly after his return from the war he became chief draftsman with the New York Steam Engine Company, New York City, in which position he remained until 1873, when he opened an office as consulting engineer. He was one of the early members of the A. S. M. E. and for many years was a contributor to our columns.

Business Items

The Independent Pneumatic Tool Company, Chicago, Ill., has received a large order for piston air drills and pneumatic hammers from the Wisconsin Engine Company, Corliss, Wis.

McGeorge Engineering Company, Cleveland, Ohio, is acting as consulting engineer for the Bridgeport (Conn.) Brass Company in connection with certain contemplated improvements.

The Winkley Company, Detroit, Mich., has purchased from the Thiem Manufacturing Company, Minneapolis, Minn., their pressed metal grease cup plant, including all machinery, tools and patent rights.

The Pittsburgh Automatic Vise and Tool Company, of Pittsburg, Penn., has been alloted the contract for vise equipment for one of the large new plants being built by Dodge & Day, engineers, of Philadelphia.

The thirty-nine stall roundhouse with adjoining tool room, offices, etc. of the Canadian Northern Railway, Winnipeg, Man., is being equipped with a complete blower system of heating and ventilation by the B. F. Sturtevant Company, of Boston, Mass.

The Scranton & Company, of New Haven, Conn., manufacturers of the Scranton improved upright power hammer, and other specialties, report that they have recently obtained additional facilities to take care of their rapidly increasing business. They expect soon to have all orders delivered complete, and to have a stock from which further orders can be promptly shipped.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Cox Computers, 75 Broad St., New York.

Caliper catalog free. E. G. Smith Co., Columbia, Pa.

Universal Test Indicator circulars free. H. A. Lowe, Lock Box 146, Cleveland, O.

Will buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Tools, dies and machinery built to order. Northwestern Machine Co., Detroit, Mich.

Expert machinist will consult and give advice. A. Frisk, 2240 Van Buren St., Chicago.

Light fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Special machinery to order, carbon and other molds specialty. O. Anderson, 30 Lawrence St., Newark, N. J.

Gas engines designed to order. Marine and automobile work a specialty. H. L. Towle, 150 Nassau street, New York.

Special machinery accurately built. Screw machine and turret-lathe work solicited. Robt. J. Emory & Co., Newark, N. J.

Manufacturers to take the manufacture of a compound simple engine on royalty basis. We invite your investigation. Box 732, AM. M.

Several mechanical tools and appliances patented to let out on royalty to responsible firms. Address Box 752, AMER. MACHINIST.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

Arrange with us to do your manufacturing; we build special machinery, special tools, etc. Lewis Blind Stitch Machine Company, 502 North Commercial St., St. Louis, Mo.

Milling Machine Wanted—Plain or universal with at least 24" longitudinal feed and all attachments for gear cutting; give full particulars and price. W. L. Lewis & Co., 128 Wythe Ave., Brooklyn, N. Y.

A large English firm of machine-tool importers, having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Wanted—Parties to manufacture at once simple automatic machines in lots of 50 to 100; larger quantities right along. For further particulars call or write to Kinetoplane Display Co., 107 West 42d St., New York City.

Isaac B. Owens, patent attorney, 100 Broadway, New York City, specialist in oil and gas engines, automobiles and automatic machinery. Patent applications entrusted to me will receive careful, personal attention, and patent secured which will protect.

Wanted—To buy patent, or manufacture under royalty, any specialty where high-grade grey iron castings constitute 60 per cent. or more of total cost; would also consider New England or Eastern rights to established article. "Founder," Care AMER. MACHINIST.

Draftsmen, engineers learn automobile drafting and designing including the latest European and American practice; the only field not overcrowded; instruction in class room and by correspondence. The New York School of Automobile Engineers, 146 West 56th Street.

Advice; mechanical, practical and technical; tell me your needs, I'll tell you the cost; lowest estimates given on fine tools, dies and presses for sheet metal goods production; have you my books? Jos. V. Woodworth, M. E., Arbuckle Building, Brooklyn, N. Y., U. S. A.

We can build machinery for quick delivery. A shop building machine tools wishes to take contracts for the construction of machinery or anything that can be produced in a foundry and machine shop. Send drawings and specifications and estimates will be made with guarantee of quick delivery. We can refer to a standard line of tools now on the market as to the quality of workmanship. Box 75, AMERICAN MACHINIST.

Wanted—A good superintendent capable of handling pattern shop, foundry and machine shop departments in a general jobbing, repairing and manufacturing shop located in a rapidly growing city of two hundred thousand inhabitants, center of a big lumbering country in the West; one who could invest about $10,000 preferred, an excellent opening for the right man. Full investigation demanded and given. Address Box 692, AMER. MACH.

Successful draftsmen drawing $125 to $200 monthly require thorough drafting room knowledge. As chief draftsman of engineering firm I know exactly the quality and quantity of experience and practical training you must have, and prepare you by mail, home instructions for above paying positions, which I furnish free anywhere. Complete highest grade drawing outfit, with German silver set of tools, value $13.85, free. Address Chief Draftsman, Div. 4, Eng.'s Equip't Co., (Inc.), Chicago.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Designer, graduate of university, with six years' practical shop and drawing room experience in machine tools and jigs desires position preferably as assistant superintendent. Box 722, AMERICAN MACHINIST.

MASSACHUSETTS

A mechanical draftsman of experience and ability (employed) desires situation in or about Buffalo; good references given. Box 753, AMERICAN MACHINIST.

Mechanical draftsman, 30 years old, technical graduate, extensive experience in drafting room and shop, wishes position. Box 765, AMERICAN MACHINIST.

NEW JERSEY

Mechanical expert, shopman, competent designer, builder, improver on tools and machinery for manufacturing. References. Box 759, AMERICAN MACHINIST.

Two expert toolmakers, one vise and one lathe hand, experienced on drill-jig, gages, model and experimental work, desire change. Box 750, AMERICAN MACHINIST.

NEW YORK

Mechanical engineer, graduate; age 26, 3 years' experience, desires change. Box 740, AMERICAN MACHINIST.

Draftsman, experienced designer on special and general machinery; New York or New Jersey preferred. Box 726, AMER. MACH.

Producer gas engines; engineer experienced in design, manufacture and installation; technical graduate; desires position with manufacturer. Box 761, AMER. MACHINIST.

Salesman—Young man; 32; experienced toolmaker and designer, well versed in shop and factory equipment appertaining to the metal industry desires an opening as salesman. Box 762, AMERICAN MACHINIST

Mechanical superintendent, employed, for personal reasons, desires to make a change; expert toolmaker, machinist, designer and manufacturing economist. Strong executive; salary secondary consideration. Box 764, AMERICAN MACHINIST.

Position as manager of works; held similar position seven years; can improve and design machinery; good mechanical, executive and business abilities; furnish best of references from concern where now employed. Box 374, AMERICAN MACHINIST.

Position of capacity wanted by crude oil engine specialist for designing, estimating, rate fixing, shop organizing, production engineering, marine work, direct connected, link reversing gears, all auxiliaries. Highest aim. Box 763, AMERICAN MACHINIST.

PENNSYLVANIA

Mechanical engineer and machine designer; 36; German; experience power transmission and textile; open for engagement; location, immaterial. Box 760, AMERICAN MACHINIST.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Wanted—First-class operator on Jones & Lamson turret lathe; also one first-class all-around machinist. The New Machine Co., Danbury, Conn.

Draftsman Wanted—Experienced in designing automatic machinery; give full particulars regarding experience, etc. The Bullard Machine Tool Co., Bridgeport, Conn.

ILLINOIS

Wanted—Several first-class vise and floor men accustomed to heavy machine tool work; steady employment and good wages. Box 685, AMERICAN MACHINIST.

Wanted—Working foreman to handle ten to twenty men on erecting heavy machine tools; good wages for right party; married man preferred. Box 684, AMERICAN MACHINIST.

Wanted—A draftsman who has had a large experience in laying out buildings and also designing them for manufacturing machinery of comparatively large size; must be thoroughly familiar with the best arrangement of buildings and the design of them such as core rooms and ovens, pattern storage buildings, etc.; what is desired is a man who will spend some time to work out the best plan before the work will be put on paper; state fully what experience you have had along the above lines and also what salary expected; if a man showed the proper ability a connection of this kind might lead up to a permanent position. Address Box 754, AM. MACH.

INDIANA

Wanted—Ten good lathe men; increasing force; good wages; steady employment. Western Motor Co., Logansport, Ind.

Wanted—Toolmakers; lathe hands, and assemblers; good wages; steady employment; Western Motor Co., Logansport, Ind.

MASSACHUSETTS

Wanted—Assistant mechanical draftsman, one used to shop methods and gear cutting preferred; state age, experience and wages expected. Address Boston Gear Works, Norfolk Downs, Mass.

Experienced mechanical draftsman wanted by manufacturing concern near Boston, Mass., for designing of jigs, fixtures and special machinery; permanent position for the right man; draftsman with practical machine shop experience preferred. Address with full particulars regarding age, education, experience and initial salary expected to Box 766, AMERICAN MACHINIST.

General machine shop foreman, by established, growing company building strictly high-grade grinding machinery and employing about 100 hands; must be thoroughly

up to date in methods; successful in handling men, and able to produce first-class work at reasonable cost; other things equal, preference will be given man with experience in grinding machines or first-class machine tools. Write fully as to experience, age, salary expected and present position; confidential if desired. Box 742, AMER. MACH.

MICHIGAN

Machinists Wanted—First-class machine hands and floor hands on heavy work; steady employment assured. Northern Engineering Works, Detroit, Mich.

Wanted—A mechanical draftsman who is thoroughly acquainted with steam pumping machinery; technical knowledge required; none but competent men need apply. Address "Steam Pumps," Care AMER. MACH.

MISSOURI

Wanted—First-class adjusters accustomed to adding machine and typewriter work. Universal Adding Machine Co., St. Louis.

Draftsman Wanted—Large lead mining company, 65 miles south of St. Louis, Missouri, wants draftsman for mechanical drafting and for making surface and underground maps; must be first-class freehand letterer and neat workman; man with knowledge of plotting and calculating survey field notes preferred; applicants please submit specimens of work and state salary wanted. Box 743, AMERICAN MACHINIST.

NEW JERSEY

Gas engine man wanted at once for installation and repair work. Steady employment. Apply, The Standard Motor Construction Co., 172 Whiton St., Jersey City, N. J.

Draftsman wanted by a firm in New Jersey; mechanical draftsman, quick and accurate, one acquainted with electrical preferred. State salary and experience. Box 755, AM. M.

Wanted—Tool, die and instrument makers accustomed to accurate, complicated work; steady work and good wages to thoroughly competent men; give references. Address Box 438, AMERICAN MACHINIST.

We are increasing our tool-making department and solicit applications from toolmakers and machinists who are experienced on fine and complicated work. Apply to Victor Talking Machine Co., Camden, N. J.

We have increased our plant and desire floor and vise hands for day work and lathe hands for night work. Good pay and steady work for good men. Address or apply at Pond Machine Tool Co., Plainfield, N. J.

Mechanical engineer—A Portland cement company located in Lehigh Valley district, which expects to build a new plant in about two years and use the present superintendent to build and operate new plant, wants engineer with experience (knowledge of cement machinery not necessary) to join present organization with view of becoming superintendent of present plant when new plant is started, provided he makes good; give details of experience and state salary expected. Address Box 749, AMERICAN MACHINIST.

NEW YORK

Patternmaker wanted. McEwen Bros., Wellsville, N. Y.

Machinists—First-class horizontal boring mill hands familiar with boring large cylinders. Address Box 751, AMER. MACHINIST.

Wanted—Experienced draftsman, toolmakers and machinists; give age, references and wages expected. Remington Arms Co., Ilion, N. Y.

Foreman for department manufacturing small parts for fine instruments; must be thoroughly competent, liberal salary. "M. F.," Box 756, AMERICAN MACHINIST.

Foreman for screw machine department employing 20 men; No. 2 and No. 00 B. & S. automatics and hand machines. Must be experienced on fine work. "E. P.," Box 758, AMERICAN MACHINIST.

Wanted—Several first-class mechanical and electrical draftsmen. Apply, giving age, experience and salary expected to Engineer in Charge, Drafting Department, General Electric Company, Schenectady, N. Y.

Foreman to take charge of department employing 25 girls, asembling watch and clock work, must be thoroughly experienced. Liberal salary and steady position to right man. "A. B.," Box 757, AMERICAN MACHINIST.

Wanted—First-class man thoroughly familiar with all kinds of tool work, one capable of handling help and filling position of responsibility. State age, experience and salary expected. Box 725, AMER. MACHINIST.

Screw machine foreman wanted to take charge of about twenty hand screw machines, steady job assured to a person combining both the mechanical and executive skill for producing high-grade output in steel; location, New York City Address Box 727, AM. M.

OHIO

Wanted—A first-class foreman for a machine shop tool room; give age, experience and salary. Address Box 748, AM. MACH.

Wanted — First-class structural engineer capable of designing steel buildings, bridges, etc.; state age, qualifications, initial salary expected, etc. Address 567, AMER. MACH.

Wanted—A foreman for a grey iron foundry employing about 120 men of all classes on work weighing up to 2½ tons; open shop and piece work; no labor trouble of any description. Address Box 730, AM. M.

PENNSYLVANIA

Wanted—First-class floor hands and fitters for machine-tool work. Colburn Machine Tool Company, Franklin, Pa.

Wanted—Capable diemakers to work on heavy drop-forge dies; steady work for the proper applicants. Apply, giving references, as well as wages expected. Box 705, AM. M.

RHODE ISLAND

We are continually adding to our force, experienced toolmakers, machinists and draftsmen on special tools, fixtures and models for light, high-grade machinery. Good wages and steady employment. Apply to Taft-Peirce Mfg. Co., Woonsocket, R. I.

VERMONT

Wanted—Foreman for erecting department in shop building machine tools; state experience and give references; good opening for the right man. Box 638, AMER. MACHINIST.

WISCONSIN

To cope with the continuous enlargement of our business, first-class machinists, patternmakers, molders and boilermakers can find steady employment. Box 899, Milwaukee.

Large concern building excavating and railway machinery wants to correspond with first-class mechanical draftsmen with view to filling future vacancies as they occur; wants men now employed; give full experience and reasons for changing; shop experience great advantage; all letters acknowledged and held confidential. Box 919, AMERICAN MACHINIST.

FOREIGN

We have increased our plant and will shortly require a large number of first-class men, as floor and vise hands, lathe hands, boilermakers and molders. We employ at present about 800 men, manufacturing locomotives and railroad cars, gas engines and steam engines. Good opportunity for the right men to return to the "old country" and build their own home. Lots to be had very cheap in beautiful surroundings, close to the shop. Good wages. Address or apply to Vagn- och Maskinfabriks Aktiebolaget, Falun, Sweden.

For Sale

For Sale—Foundry, wood and iron machine shop. Box 74, Albion, N. Y.

For Sale—Machine shop; 250 feet ground, $4250. Morgan Dickort, Chattanooga, Tenn.

For Sale—One 2" Cleveland automatic screw machine in perfect condition can be seen in operation. Fishback Mfg. Co., 96 Brush St., Detroit, Mich.

For Sale—Cyclopedia of modern shop practice, four volumes; bound in green morocco leather. Practically new; cost $18; will sell for $6. Address L. N. O., Box 425, Chicago, Ill.

Boilers—Battery of two 150 h.p. Babcock and Wilcox water tube boilers for 100 lb. pressure; first-class condition; complete, all trimmings. Nathan Manufacturing Company, 416 East 106th Street, New York City.

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Boring and Drilling Machines, Horizontal—*Cont.*
Vandyck Churchill Co., New York.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Betts Mach. Co., Wilmington, Del.
Bullard Mach. Tool Co., Bridgeport, Conn.
Colburn Mach. Tool Co., Franklin, Pa.
Gisholt Mach. Co., Madison, Wis.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
McCabe, J. J., New York.
Niles-Bement-Pond Co., New York.
Poole Co., J. Morton, Wilmington, Del.
Prentiss Tool & Supply Co., New York.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Warner & Swasey Co., Cleveland, Ohio.

Boring Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Carr Bros., Syracuse, N. Y.
Fairbanks Co., Springfield, Ohio.

Boxes, Tote
Lyon Metallic Mfg. Co., Aurora, Ill.

Brackets, Lamp
Standard Welding Co., Cleveland, Ohio.

Brakes, Magnetic Friction
Electric Controller & Supply Co., Cleveland, O.

Broaching Machines
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Lapointe Mach. Tool Co., Hudson, Mass.

Bulldozers
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Prentiss Tool & Supply Co., New York.

Cabinets, Tool
Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Lyon Metallic Mfg. Co., Aurora, Ill.

Calipers
Athol Mach. Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Sawyer Tool Mfg. Co., Fitchburg, Mass.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Cams
Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum
See Grinding Wheels

Carriers
Lamson Consolidated S. S. Co., Boston, Mass.

Castings, Brass and Bronze
Lumen Bearing Co., Buffalo, N. Y.
Nolte Brass Co., Springfield, O.
Phosphor Bronze Smelting Co., Philadelphia, Pa.

Castings, Die Molded
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Castings, Iron
Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Fairbanks Co., Springfield, O.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Hopson & Chapin Mfg. Co., New London, Conn.
Poole Co., J. Morton, Wilmington, Del.
United Engineering & Fdry. Co., Pittsburg, Pa.

Castings Steel
Bethlehem Steel Co., So. Bethlehm, Pa.
Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Kent & Co., Edwin R., Chicago, Ill.

Cement, Cast Steel
Clark Cast Steel Cement Co., Shelton, Conn.

Centering Machines
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Hendey Mach. Co., Torrington, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Phœnix Mfg. Co., Hartford, Conn.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving
Baldwin Chain & Mfg. Co., Worcester, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
Whitney Mfg. Co., Hartford, Ct.

Chisels, Cold
Hammacher, Schlemmer & Co., New York.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Chucking Machines
American Tool Wks. Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Mach. Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, Ohio.
Potter & Johnston Mach. Co., Pawtucket, R. I.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.
Windsor Mach. Co., Windsor, Vt.

Chucks, Drill
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Brown Co., R. H., New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Horton & Son Co., E., Windsor Locks, Conn.
Jacobs Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Niles-Bement-Pond Co., New York.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Standard Tool Co., Cleveland, O
Trump Bros. Mach. Co., Wilmington, Del.
Wells Bros. Co., Greenfield, Mass
Whitney Mfg. Co., Hartford, Ct.
Whiton Mach. Co., D. E., New London, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Chucks, Lathe
Cushman Chuck Co., Hartford, Conn.
Gisholt Mach. Co., Madison, Wis.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Son Co., E., Windsor Locks, Conn.
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Ct.
Whiton Mach. Co., D. E., New London, Conn.

Chucks, Planer
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain Conn.

Chucks, Split
Rivett Lathe Mfg. Co., Boston, Mass.

Circuit Breakers
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps
Billings & Spencer Co., Hartford, Conn.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Tudor Mfg. Co., Worcester, Mass.

Clutches, Friction
Caldwell, Son & Co., H. W., Chicago, Ill.
Cresson Co., Geo. V., Phila., Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Wood's Sons Co., T. B., Chambersburg, Pa.

Clutches, Magnetic
Electric Controller & Supply Co., Cleveland, Ohio.

Coal Handling Machinery
Link-Belt Co., Philadelphia, Pa.

Coils
Standard Welding Co., Cleveland, Ohio.

Collectors, Pneumatic
Sturtevant Co., B. F., Boston, Mass.

Compound, Pipe Joint
Dixon Crucible Co., Joseph, Jersey City, N. J.

Compound, Slushing
Warren Bros. Co., Boston, Mass.

Compressors, Air
Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Boston, Mass.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
International Steam Pump Co., New York.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas
Ingersoll-Rand Co., New York.

Conduit, Interior
Sprague Electric Co., New York.

Cones, Friction
Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps
Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work
Blanchard Mach. Co., Boston, Mass.
Chapman & Co., J. B., Springfield, Mass.
Skinner Ship Bldg. & Dry Dock Co., Baltimore, Md.
Turner Mach. Co., Danbury, Conn.

Controllers and Starters, Electric Motor
Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic
Lamson Consol. S. S. Co., Boston, Mass.
Link-Belt Co., Philadelphia, Pa.

Coping Machines
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Cork Inserts
National Brake & Clutch Co., Boston, Mass.

Corundum
See Grinding Wheels

Cost Systems
American Mechanical Calculator Co., Cincinnati, O.

Cotters
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.

Countershafts
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders' Iron Fdry., Prov., R. I.
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Mossberg Wrench Co., Central Falls, R. I.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction
Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing
Cresson Co., Geo. V., Phila., Pa.
Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose
Ingersoll-Rand Co., New York.

Couplings, Shaft
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cresson Co., Geo. V., Phila., Pa.
Electric Controller & Supply Co., Cleveland, Ohio.
Link-Belt Co., Philadelphia, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.
Wood's Sons Co., T. B., Chambersburg, Pa.

Cranes
Alliance Machine Co., Alliance, O.
Brown Hoisting Mach. Co., Cleveland, Ohio.
Case Mfg. Co., Columbus, O.
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Maris Bros., Philadelphia, Pa.
Nicholls, Wm. S., New York.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.

Cranes—*Continued.*
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
United Engineering & Fdry. Co., Pittsburg, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines
Niles-Bement-Pond Co., New York.

Crank Shafts
Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles
Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas, and Ladles, Foundry
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups and Covers, Oil
Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.
Winkley Co., Detroit, Mich.

Cups, Grease
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cutters, Milling
Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Boker & Co., Hermann, New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Nash Company, Geo., New York.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines
Armstrong Bros. Tool Co., Chicago, Ill.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Hill, Clarke & Co., Inc., Boston, Mass.
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Newton Mach. Tool Works, Philadelphia, Pa.
Nutter, Barnes & Co., Boston, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Fairbanks Co., Springfield, Ohio.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.

Diamond Tools
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Dickinson, Thos. L., New York City.

Dies, Sheet Metal
American Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Kent & Co., Edw. R., Chicago, Ill.
Mossberg Wrench Co., Central Falls, R. I.
Wade Machine Co., Boston, Mass.

Dies, Sub-Press
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Opening
Baker, S. S., Chicago, Ill.
Boker & Co., Hermann, New York.
Errington, F. A., New York.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Mach. Co., Springfield, Vt.
Modern Tool Co., Erie, Pa.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins
Winkley Co., Hartford, Conn.

Drawing Boards and Tables
Alteneder & Son, Theo., Philadelphia, Pa.
Economy Drawing Table Co., Toledo, Ohio.
Keuffel & Esser Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Rich, J. & G., Philadelphia, Pa.
Soltmann, E. G., New York.

Drawing Materials
Alteneder & Son, Theo., Philadelphia, Pa.
American Tracing Cloth Co., New York.
Keuffel & Esser Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Rich, J. & G., Philadelphia, Pa.
Soltmann, E. G., New York.
Technical Supply Co., Scranton, Pa.

Drafting Machines
Universal Drafting Mach. Co., Cleveland, O.

Drift Bolt Drivers
Ingersoll-Rand Co., New York.

Drilling Machines, Bench
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Dwight Slate Mach. Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Ingersoll-Rand Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Boiler
American Tool Wks. Co., Cin., O.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, Ohio.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Electric
Chicago Pneumatic Tool Co., Chicago, Ill.

Drilling Machines, Multiple Spindle
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co. B. F., Rockford, Ill.
Barnes Co. W. F. & John, Rockford, Ill.
Baush Mach. Tool Co. Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.

Drilling Machines, Multiple Spindle—*Continued.*
Fenn Mach. Co., Hartford, Conn.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Harrington Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.

Drilling Machines, Portable
Cincinnati Elec. Tool Co., Cin., O.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial
American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Detrick & Harvey Mach. Co., Baltimore, Md.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Fdry. Co., Jno. B., Cincinnati, O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

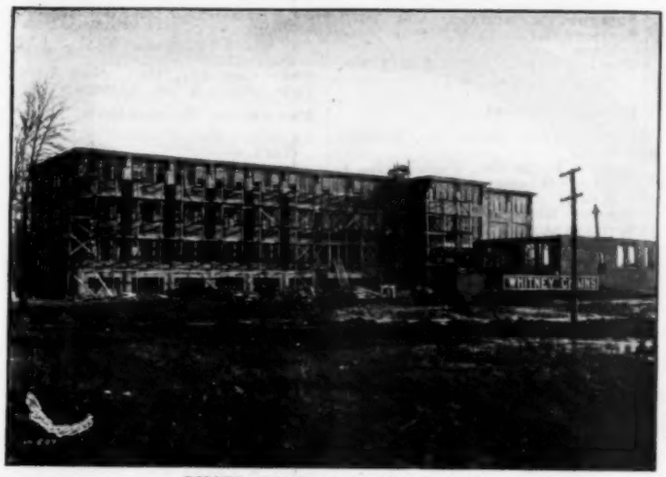
Drilling Machines, Turret
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright
American Tool Wks. Co., Cin., O.
Baker Bros, Toledo, O.
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co., Cincinnati, O.
Fenn Mach. Co., Hartford, Conn.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, Ohio.
Knight Machry. Co., W. B., St. Louis, Mo.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.

"Whitney" Chains

In 1907 will break all previous records for durability

We are moving into our new fire-proof factory building and will operate both plants, old and new, until we are fully settled so our production may be steadily increased with no interruption.



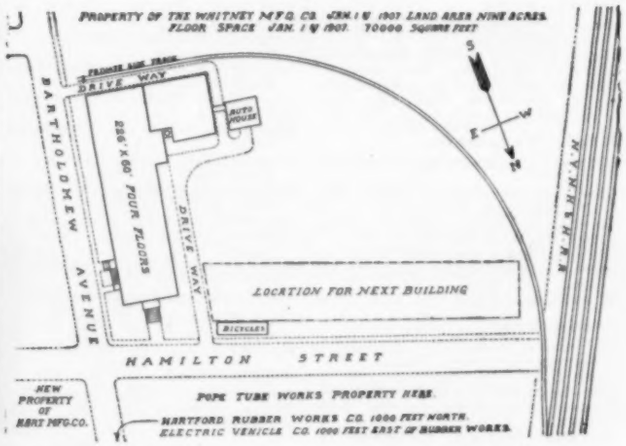
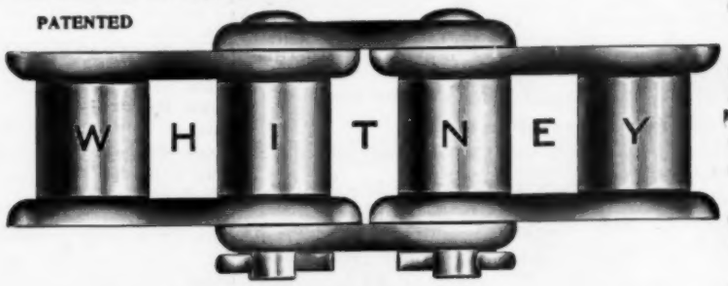
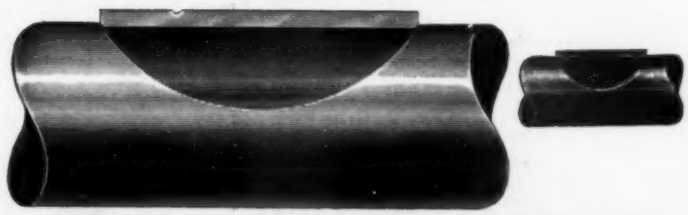

PROPERTY OF THE WHITNEY MFG. CO. JAN. 1 '07. LAND AREA NINE ACRES.
FLOOR SPACE JAN. 1 '07. 70000 SQUARE FEET
DRIVE WAY
BARTHOLOMEW AVENUE
286 X 60 FOUR FLOORS
DRIVE WAY
LOCATION FOR NEXT BUILDING
BICYCLES
HAMILTON STREET
NEW PROPERTY OF HART MFG CO.
POPE TUBE WORKS PROPERTY HERE.
HARTFORD RUBBER WORKS CO. 1000 FEET NORTH.
ELECTRIC VEHICLE CO. 1000 FEET EAST OF RUBBER WORKS.

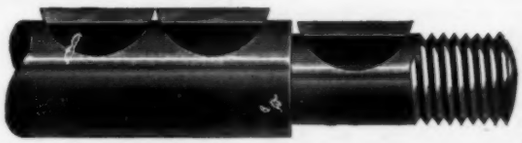
PHOTO. TAKEN JANUARY 6, 1907.

This cut gives an idea only of the plant which we believe will be the finest and most complete in existence for the manufacture of High Grade Driving Chains.

PATENTED







"Whitney" Chains

HAND AND WEIGHT FEED MILLING MACHINES, and The Woodruff Patent System of Keying

are Standard with most American Builders of Automobiles, Commercial Cars, Machinery, etc.

The Whitney Mfg. Co.

Hartford Connecticut

Drilling Machines, Upright —*Continued.*
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Ct.
Wells Bros. Co., Greenfield, Mass.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Drills, Center
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand
Cincinnati Electrical Tool Co., Cincinnati, O.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
International Steam Pump Co., New York.
Niles-Bement-Pond Co., New York.

Drills, Rail
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Foote-Burt Co., Cleveland, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Hisey-Wolf Mach. Co., Cincin., O.
Keystone Mfg. Co., Buffalo, N. Y.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

Drills, Rock
Ingersoll-Rand Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.

Drying Apparatus
Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos
Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
Eck Dynamo & Motor Works, Belleville, N. J.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. Co., Chicago, Ill.
Sprague Elec. Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincin., O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrical Supplies
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Elec. Co., New York.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrically Driven Tools and Machinery
American Tool Wks. Co., Cin., O.
Cincinnati Electrical Tool Co., Cincinnati, O.
Crescent Forgings Co., Oakmont, Pa.
Electric Controller & Supply Co., Cleveland, O.

Electrically Driven Tools and Machinery —*Continued.*
Hisey-Wolf Mach. Co., Cincin., O.
Lincoln Motor Wks. Co., Cleveland, O.
Ransom Mfg. Co., Oshkosh, Wis.
Roth Bros. Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.

Elevators
Albro-Clem Elevator Co., Philadelphia, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.

Emery Wheels
See Grinding Wheels

Emery Wheel Dressers
American Emery Wheel Co., Providence, R. I.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Dickinson, Thos. L., New York City.
Heald Machine Co., Worcester, Mass.
International Specialty Co., Detroit, Mich.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

Enclosures, Tool-room
Hart & Cooley Co., New Britain, Conn.
Merritt & Co., Philadelphia, Pa.

Engineering Appliances
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Engineers, Consulting and Mechanical
Dodge & Day, Philadelphia, Pa.
Thompson, Hugh L., Waterbury, Conn.

Engineers, Electrical
Crocker-Wheeler Co., Ampere, N. J.
Dodge & Day, Phila., Pa.

Engines, Automobile
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Olds Gas Power Co., Lansing, Mich.

Engines, Gas and Gasolene
Automatic Mach. Co., Bridgeport, Conn.
Backus Water Motor Co., Newark, N. J.
Blaisdell Machinery Co., Bradford, Pa.
Foos Gas Engine Co., Springfield, Ohio.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Jacobson Mach. Mfg. Co., Warren, Pa.
New Era Gas Engine Co., Dayton, O.
Olds Gas Power Co., Lansing, Mich.
St. Marys Mach. Co., St. Marys, Ohio.
Struthers-Wells Co., Warren, Pa.

Engines, Steam
Buffalo Forge Co., Buffalo, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Engravers
Bormay Engraving Co., New York.
Standard Engraving Co., New York.

Engraving Machinery
Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads
Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition Machinery
Machinery Exchange, Boston, Mass.
Philadelphia Bourse, Phila., Pa.

Expanders, Tube
Nicholson & Co., Wm., Wilkes-Barre, Pa.

Facing Machines, Portable
Underwood & Co., H. B., Philadelphia, Pa.

Factory Equipment
Lyon Metallic Mfg. Co., Aurora, Ill.

Fans, Electric
Backus Water Motor Co., Newark, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust
Backus Water Motor Co., Newark, N. J.
Buffalo Forge Co., Buffalo, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Feathers
Standard Gauge Steel Co., Beaver Falls, Pa.

Files and Rasps
American Swiss File & Tool Co. New York.
Barnett Co., G. & H., Phila., Pa.
Hammacher, Schlemmer & Co., New York.
Nicholson File Co., Prov., R. I.
Reichheim & Co., E. P., New York.

Filler, Iron
Felton, Sibley & Co., Phila., Pa.

Filing Machines
Cochrane-Bly Co., Rochester, N. Y.
Detrick & Harvey Mach. Co., Baltimore, Md.
Henry & Wright Mfg. Co., Hartford, Conn.
Simplex Mfg. Co., New York.

Flexible Shafts
Chicago Flexible Shaft Co., Chicago, Ill.
Coates Clipper Mfg. Co., Worcester, Mass.

Forges
Boynton & Plummer, Worcester, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Buffalo Forge Co., Buffalo, N. Y.
Ingersoll-Rand Co., New York.
Miner & Peck Mfg. Co., New Haven, Conn.
Prentiss Tool & Supply Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Forgings, Drop
Bethlehem Steel Co., So. Bethlehem, Pa.
Billings & Spencer Co., Hartford, Conn.
Crescent Forgings Co., Oakmont, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Page-Storms Drop Forge Co., Springfield, Mass.
Wyman & Gordon Co., Worcester, Mass.

Forgings, Hydraulic
Bethlehem Steel Co., So. Bethlehem, Pa.
Wyman & Gordon Co., Worcester, Mass.

Forgings, Machine
Dyson & Sons, Jos., Cleveland, O.

Forgings, Steel
Baldwin Steel Co., New York.
Bethlehem Steel Co., So. Bethlehem, Pa.
Crescent Forgings Co., Oakmont, Pa.

Forgings, Steel—*Continued.*
Heppenstall Forge & Knife Co., Pittsburg, Pa.
Kent & Co., Edwin R., Chicago, Ill.
Tindel-Morris Co., Eddystone, Pa.
Wyman & Gordon Co., Worcester, Mass.

Foundry Furnishings
Adams Co., Dubuque, Iowa.
Ingersoll-Rand Co., New York.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Fuel Economizers
Sturtevant Co., B. F., Hyde Park, Mass.

Furnaces, Annealing and Tempering
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Tate, Jones & Co., Pittsburg, Pa.

Furnaces, Enameling
American Gas Furnace Co., New York.

Furnaces, Gas
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Obermayer Co., S., Cincinnati, O.
Westmacott, J. M., Prov., R. I.

Furnaces, Melting
American Gas Furnace Co., New York.
Nash Company, Geo., New York.
Turner Brass Works, Chicago, Ill.

Furnaces, Oil
Tate, Jones & Co., Pittsburg, Pa.

Furniture, Machine Shop
Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.
Manufacturing Equip. & Engineering Co., E. Boston, Mass.
Merritt & Co., Philadelphia, Pa.
New Britain Mach. Co., New Britain, Conn.

Gas Blowers and Exhausters
Sturtevant Co., B. F., Hyde Park, Mass.

Gages, Recording
Bristol Co., Waterbury, Conn.

Gages, Standard
Brown & Sharpe Mfg. Co., Providence, R. I.
Henry & Wright Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Gages, Steam
Crosby Steam Gage & Valve Co., Boston, Mass.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gear Cutting Machinery
Adams Co., Dubuque, Iowa.
Bair & Gazzam Mfg. Co., Pittsburg, Pa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Bilgram, Hugo, Philadelphia, Pa.
Brown & Sharpe Mfg. Co., Providence, R. I.
Clough, R. M., Tolland, Conn.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant-Lees Mach. Co., Cleveland, Ohio.
Harrington, Sons & Co., Edwin, Philadelphia, Pa.
Newton Machine Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.

Brown & Sharpe Mfg. Co.,
Providence, R. I., U. S. A.

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Gear Cutting Machinery —*Continued.*
Prentiss Tool & Supply Co., New York.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Walcott & Son, Geo. D., Jackson, Mich.
Whiton Machine Co., D. E., New London, Conn.

Gear Testing Machinery
Gisholt Mach. Co., Madison, Wis.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Gears, Cut
Bair & Gazzam Mfg. Co., Pittsburg, Pa.
Bilgram, Hugo, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., Chicago, Ill.
Cresson Co., Geo. V., Phila., Pa.
Davis, Rodney, Philadelphia, Pa.
Earle Gear & Mach. Co., Philadelphia, Pa.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant Gear Wks., Boston, Mass.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Horsburgh & Scott Co., The, Cleveland, Ohio.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Patterson, Gottfried & Hunter, Ltd., New York.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Wks., Cleveland, O.
Simonds Mfg. Co., Pittsburg, Pa.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Son, Geo. D., Jackson, Mich.

Gears, Molded
Caldwell & Son Co., H. W., Chicago, Ill.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Greenwald Co., I. & E., Cin., O.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Walcott & Son, Geo. D., Jackson, Mich.

Gears, Rawhide
Boston Gear Works, Norfolk Downs, Mass.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Horsburgh & Scott Co., Cleveland, O.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Works, Cleveland, O.

Gears, Worm
Albro-Clem Elevator Co., Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Simonds Mfg. Co., Pittsburg, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Son, Geo. D., Jackson, Mich.

Generating Sets
Burke Electric Co., Erie, Pa.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.

Generating Sets—*Continued.*
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, O.

Generators, Gas
American Gas Furnace Co., New York.

Gibs
Standard Gauge Steel Co., Beaver Falls, Pa.

Graphite
Dixon Crucible Co., Jos., Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Grinders, Automatic Knife
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.

Grinders, Center
Cincinnati Electrical Tool Co., Cincinnati, O.
Coates Clipper Mfg. Co., Worcester, Mass.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cin., O.

Grinders, Cock
Windsor Mach. Co., Windsor, Vt.

Grinders, Cutter
Bath Grinder Co., Fitchburg, Mass.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, O.
Crocker-Wheeler Co., Ampere, N. J.
Garvin Machine Co., New York.
Gould & Eberhardt, Newark, N. J.
Greenfield Mach. Co., Greenfield, Mass.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Niles-Bement-Pond Co., New York.
Norton Co., Worcester, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Rivett-Dock Co., Boston, Mass.
Wells & Sons Co., F. E., Greenfield, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinders, Cylindrical
Bath Grinder Co., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Heald Mach. Co., Worcester, Mass.
Norton Grinding Co., Worcester, Mass.

Grinders, Disk
Bath Grinder Co., Fitchburg, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Diamond Mach. Co., Prov., R. I.
Gardner Machine Co., Beloit, Wis.
Heald Mach. Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Iroquois Mach. Co., New York.
Ransom Mfg. Co., Oshkosh, Wis.
Rowbottom Machine Co., Waterbury, Conn.
Safety Emery Wheel Co., Springfield, O.

Grinders, Drill
Heald Mach. Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinders, Internal
Bath Grinder Co., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Greenfield Mach. Co., Greenfield, Mass.
Heald Mach. Co., Worcester, Mass.

Grinders, Internal—*Continued*
Rivett Lathe Mfg. Co., Boston, Mass.
Wells & Sons Co., F. E., Greenfield, Mass.

Grinders, Piston Ring
Heald Mach. Co., Worcester, Mass.

Grinders, Portable
Cincinnati Electrical Tool Co., Cincinnati, O.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
U. S. Electrical Tool Co., Cin., O.

Grinders, Saw
Tindel-Morris Co., Eddystone, Pa.

Grinders, Tool
Armstrong Bros. Tool Co., Chicago, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Fitchburg, Mass.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Electrical Tool Co., Cincinnati, O.
Diamond Mach. Co., Prov., R. I.
Gisholt Mach. Co., Madison, Wis.
Gould & Eberhardt, Newark, N. J.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Heald Mach. Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Landis Tool Co., Waynesboro, Pa.
Modern Tool Co., Erie, Pa.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Niles-Bement-Pond Co., New York.
Ransom Mfg. Co., Oshkosh, Wis.
Rivett Lathe Mfg. Co., Boston, Mass.
Safety Emery Wheel Co., Springfield, O.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
U. S. Electrical Tool Co., Cincinnati, O.
Vandyck Churchill Co., New York.
Vitrified Wheel Co., Westfield, Mass.
Whitney Mfg. Co., Hartford, Ct.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinding and Polishing Machinery
Abrasive Material Co., Philadelphia, Pa.
American Emery Wheel Co., Providence, R. I.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Fitchburg, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Electrical Tool Co., Cincinnati, O.
Coates Clipper Mfg. Co., Worcester, Mass.
Crocker-Wheeler Co., Ampere, N. J.
Diamond Mach. Co., Prov., R. I.
Goodell-Pratt Co., Greenfield, Mass.
Graham Mfg. Co., Prov., R. I.
Greenfield Mach. Co., Greenfield, Mass.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Iroquois Mach. Co., New York.
Landis Tool Co., Waynesboro, Pa.
Marshall & Huschart Machry. Co., Chicago, Ill.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Norton Co., Worcester, Mass.
Norton Grinding Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Ransom Mfg. Co., Oshkosh, Wis.
Royersford Fdry. & Machine Co., Royersford, Pa.

Grinding and Polishing Machinery —*Continued.*
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vandyck Churchill Co., New York.
Vitrified Wheel Co., Westfield, Mass.
Wells Sons Co., F. E., Greenfield, Mass.

Grinding Wheels
Adams Co., Dubuque, Iowa.
American Emery Wheel Co., Providence, R. I.
Builders' Iron Foundry, Providence, R. I.
Carborundum Co., Niagara Falls, N. Y.
Cortland Cor. Wheel Co., Cortland, N. Y.
Diamond Mach. Co., Prov., R. I.
Hampden Corundum Wheel Co., Brightwood, Mass.
Niles-Bement-Pond Co., New York.
Norton Co., Worcester, Mass.
Pike Mfg. Co., Pike, N. H.
Safety Emery Wheel Co., Springfield, O.
Superior Corundum Wheel Co., Waltham, Mass.
Vitrified Wheel Co., Westfield, Mass.
Whitney Mfg. Co., Hartford, Ct.
Worcester Emery Wheel Co., Worcester, Mass.

Grindstones and Frames
Athol Machine Co., Athol, Mass.
Niles-Bement-Pond Co., New York.
Pike Mfg. Co., Pike, N. H.

Gun Barrel Machinery
Diamond Mach. Co., Prov., R. I.
Pratt & Whitney Co., Hartford, Conn.

Hammers, Drop
Billings & Spencer Co., Hartford, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Bradley & Son, C. C., Syracuse, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Gould & Eberhardt, Newark, N. J.
Miner & Peck Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.

Hammers, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Ingersoll-Rand Co., New York.
International Steam Pump Co., New York.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Hammers, Power
Beaudry & Co., Inc., Boston, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Scranton & Co., New Haven, Ct.

Hammers, Steam
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bethlehem Fdry. & Mach. Co., So. Bethlehem, Pa.
Bradley & Son, C. C., Syracuse, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Crescent Forgings Co., Oakmont, Pa.
Marshall & Huschart Machinery Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Handles, Machine Tool
Cincinnati Ball Crank Co., Cincinnati, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Hangers, Shafting
Cresson Co., Geo. V., Phila., Pa.
Link-Belt Co., Philadelphia, Pa.
Wood's Sons Co., T. B., Chambersburg, Pa.

Heaters, Feed Water
Sturtevant Co., B. F., Hyde Park, Mass.

An Italian Motor Works

Illustrating the Various Departments of the Fiat Works, One of the Leading Automobile Builders in Europe

BY I. W. CHUBB

The advent of Italy as a competitor among the nations in the automobile industry was first noted especially in Great Britain on the occasion of the motor show held in March, 1906, at the Agricultural Hall, London, N. Here Italian cars were for the first time prominently exhibited. Following this lead, quite a number of Italian productions were to be seen at the recent show at Olympia, London, W. also in New York and Bombay. In addition to motor cars and motor omnibuses, the company also makes marine motors, lorries, and lighter delivery vans.

The works in Turin employ 3000 men and have 41,000 square meters floor area.

Where They Go

Of the total production of 35 to 40 machines a week, one-quarter is to supply the home demand; the remaining machines are exported. The United States appears to be the largest customer, taking something like one-fifth of the output. The exports to Great Britain, France and Germany are about equal, and together approach the home demand plus American consumption. The balance is spread over various countries, including India and China. Last summer the firm had an order for 1907 for the gear for 1000 ordinary and 800 motor vehicles. The latter included 150 for England, their main feature being low-speed motors and the use of four brakes.

Details of the Engine

Most of the engines supplied have four cylinders or multiples of four, the power being usually 16, 24, 40, 50 and 100, and then up to 300 horse-power or more for motor boats.

A view of the motor-erecting shop is given in Fig. 1.

The machines used in the manufacture of the motors are mostly American, although a range of German tools is to be noted, including vertical boring machines, as in Fig. 2. Some French duplex boring machines are used on the gear boxes. The drill presses throughout the works are of almost every description, and while most are American, a number are of German make. Along the front row of the lathes, Springfield and Hendey-Norton productions were particularly noted, while in the automatic department, machines by Potter & Johnston, Herbert, and Gisholt may be particularized, as well as a number of Loewe machines and Jones & Lamson tools.

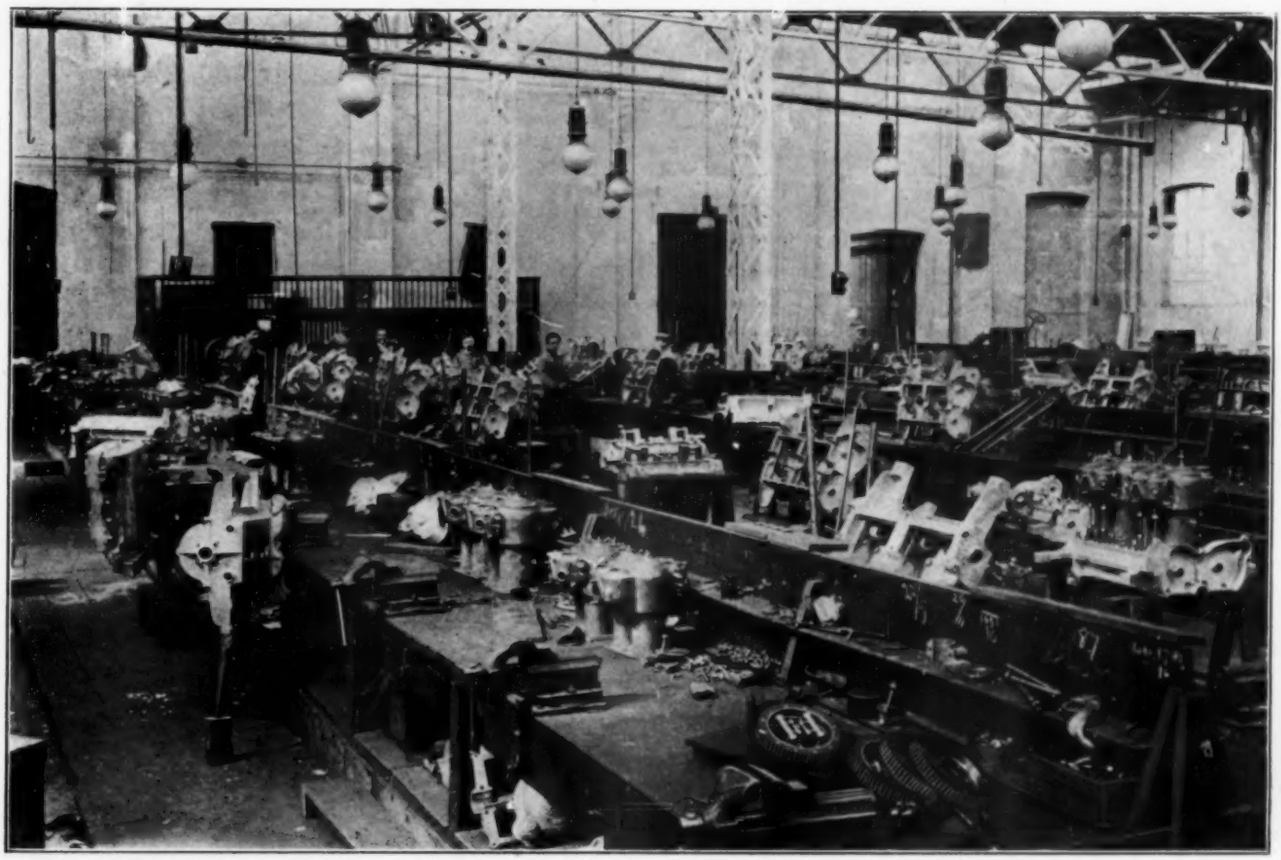


FIG. 1. MOTOR-ERECTING SHOP

Foremost of the Italian firms is the company called La Fabrica Italiana di Automobile di Torino, better, perhaps, known as the Fiat Company of Turin.

The motor industry is of comparatively recent growth anywhere, but especially so in northern Italy. The Fiat Company, however, can claim to be the oldest of the Italian firms, having been founded in 1899. The works are fairly well concentrated in Turin and, in addition, garages and repair shops connected directly or indirectly with the firm may be found in London, Paris, Berlin, Vienna, Brussels, Milan and many other European towns;

Many Automatic Machines

The crowded character of the automatic-machine department may be gathered from Fig. 3.

FIGS. 2 AND 3. BORING DEPARTMENT AND AUTOMATIC-MACHINE DEPARTMENT

The section devoted mainly to gear boxes is illustrated in Fig. 4. Fig. 5 shows the frame-fitting shop, Fig. 6 further illustrating the fitting up of shown in Fig. 7 is now being devoted to other purposes, and the parts are to be fitted and assembled mostly in the new works. The testing room for motors, illustrated in Fig. 8, is arranged at the side of the general fitting shop. In one of the fitting shops, a feature is the use of small store rooms, placed at each corner.

Overhead Shafting Used

The drive in all the shops is from overhead shafting by belt down to the machine. The overhead shafts, however, are arranged in parallel rows, each driven by its own electric motor supplied from the public mains. Overhead cranes are not used, hand cranes being sufficient for the weights to be moved. The roof as a rule is carried on light columns; the floor is of concrete.

FIG. 4. WHERE THE GEAR BOXES ARE MADE

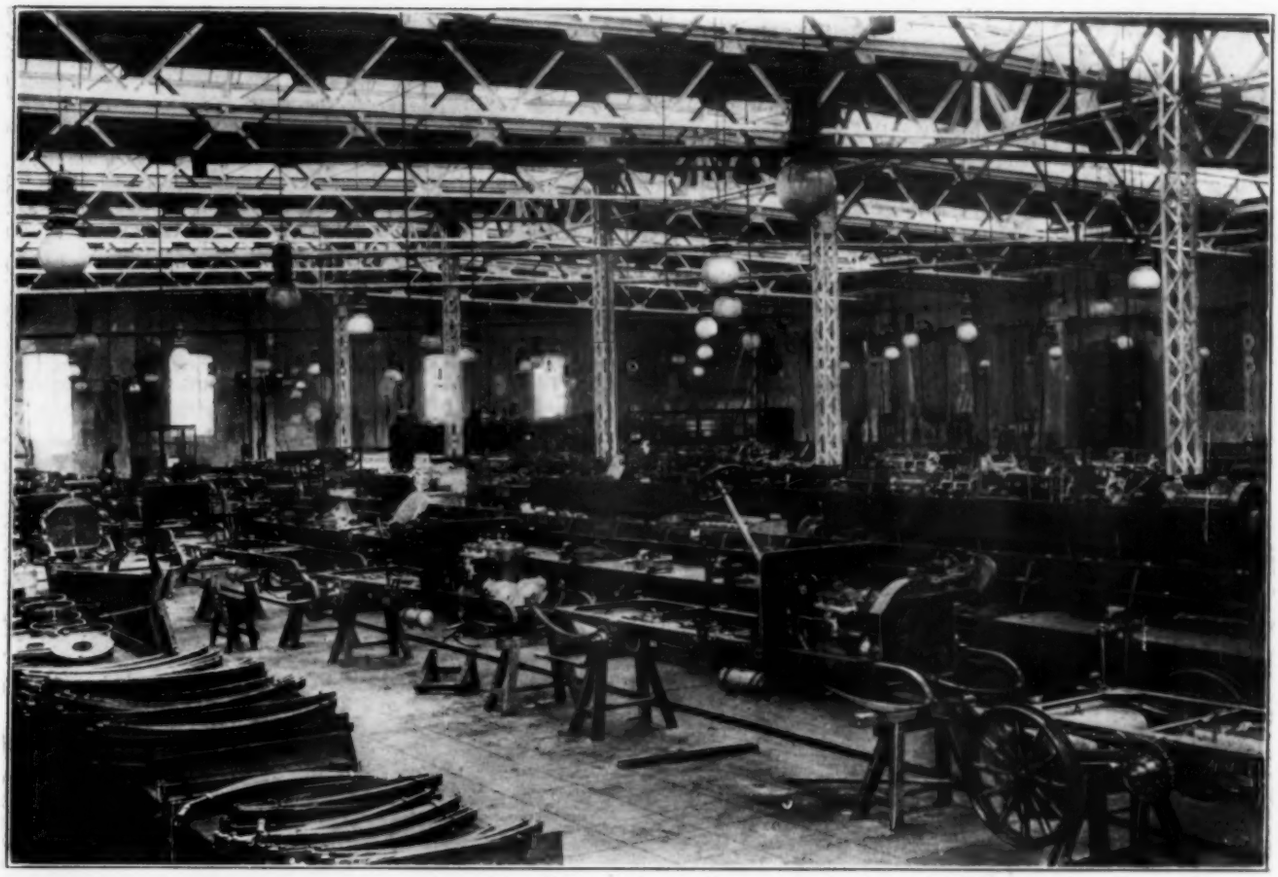


FIG. 5. FRAME-ERECTING SHOP

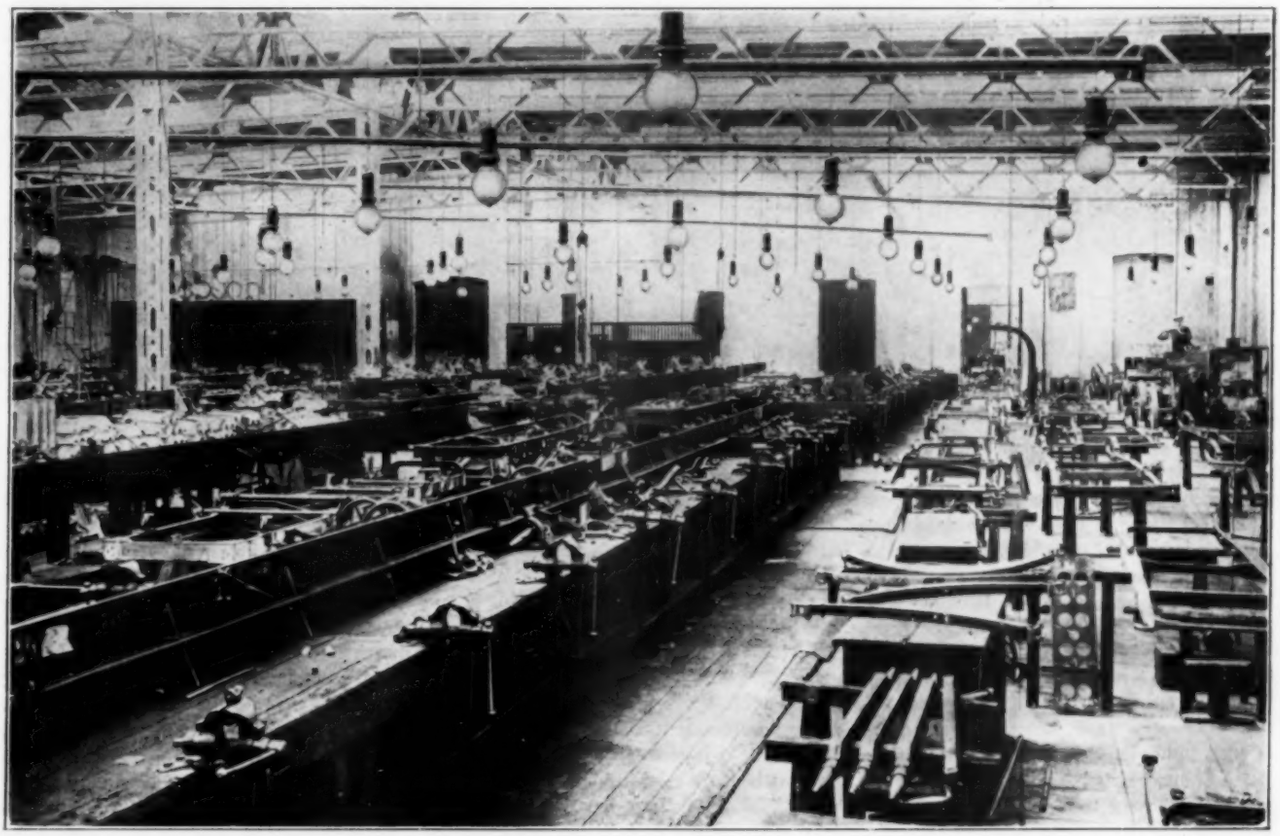


FIG. 6. FITTING SHOP FOR MOTORS AND FRAMES

Purchasing a Lathe

By W. T. Sears

Having had a number of years' experience in the designing, selling and purchasing of lathes, it is very firmly impressed upon my mind that the average purchaser of a lathe does not, in many cases, get what he wants or get the proper value for his money. In other words, the machine he finally decides upon and buys is not the machine best adapted to his needs. The result of this is that the purchaser is dissatisfied and the manufacturer's prestige suffers.

The first step in the purchase of a lathe should be a most intelligent investigation of what its duties are to be.

In some shops where the number of tools is limited and a very wide range of work is handled, then, possibly, the best thing to do is to get a lathe of a very wide range of speeds and feeds which will thus handle the average work of the shop to fairly good advantage, but not work economically on perhaps many of them. The demand of shops of this kind is, today, however, small, and 90 per cent. of the lathes sold today unquestionably go to shops of such a size and with sufficient machinery to allow the lathe to be kept on practically one class of work a very large proportion of its time.

In sending out inquiries, therefore, it is necessary, in order to get the best results, that the purchaser should have an intelligent idea of the work he expects to handle and keep the range of his requirements down as much as possible. In the endeavor to take care of an odd 10 per cent. or 15 per cent. of his work, the purchaser will, many times, sacrifice a large percentage of the economy possible to be obtained on the remainder. This does not mean that a special lathe should be built for every separate line of work or that every standard tool must be modified to meet special requirements, for the fact is that there is, undoubtedly, on the market, some standard lathe which will very nearly meet the purchaser's requirements and this lathe or its equivalent modified from some other standard line is the one wanted.

Take, for instance, a 30-inch lathe which swings approximately 21 inches over the carriage. The chances are that a lathe of this sort in some certain machine shop will be at work nearly all of the time on material ranging from six inches to 18 inches. If brass work or polishing is to be done on it, then, naturally, its speed range would extend to a somewhat higher point than if it were to work all the time on cast iron or steel; but we may say, at present, that this is rather exceptional.

In most cases, it will, undoubtedly, be found that this lathe could be kept on practically one class of work. This being the case, the speeds and feeds should be such as to turn out this line of work to the greatest advantage. For instance, suppose the work for a long period was 10 inches in diameter and then for another long period 11 inches, it would be anything but economical to purchase a lathe giving the proper cutting speed for 10 inches and with a speed range called for so great that the next step above 10 inches at which proper cutting speed could be obtained would be 12 inches. In other words, it would be far better to drop the end speeds, which are seldom used, condensing the range and making the difference between the steps much less.

Another point to be considered is the size of the cuts to be taken. The introduction of high-speed steels has here made a great difference, but care should be taken that specifications by the purchaser are not drawn so as to, in the first place, force a thoroughly conscientious manufacturer to offer a machine which must be new and special throughout to meet these requirements, or have some other manufacturer offer a machine which will not live up to these specifications, but which he (the manufacturer) is willing to take chances on, owing to the conviction that the purchaser does not actually know exactly what he does want and is asking for more than he will ever need or use.

FIG. 7. ERECTING SHOP

The only intelligent way for a purchaser to handle the matter, provided he has the assurance of the responsible builder that his demands are excessive, is for him to compare weights and dimensions of the standard machines in competition, unless he is willing to pay what may seem to him high for a machine built specially to meet his demands.

In this connection it is certainly advisable to call attention to the fact that no mechanism transmitting power is stronger than its weakest part, and that a heavy belt or heavy motor, heavy gearing or heavy tool post is of no use unless the proportion is the same throughout.

A 6-inch belt can be put on a 16-inch lathe, the gearing made heavy enough to transmit all the belt will deliver, and the carriage in proportion; but if the feed mechanism is weak or the bed is not stiff enough, the additional money spent for these exceptionally strong parts is entirely thrown away and had much better be spent elsewhere on the machine. In case the purchaser is unable to give an intelligent summary of the majority of the work he proposes to do on the lathe and most of the duties it is to be called upon to perform, the only reasonable course for him is to ask for prices and dimensions of standard machines, and, when these are at hand, compare them one with the other, as before suggested, keeping in mind always the responsibility and reputation of the different bidders.

It is very seldom, however, that the source of the demand for more lathes could not be made the source of information as to special requirements desired.

The purchaser should also consider into whose hands the lathe is going and the treatment it will receive. If it is to be placed in a tool room, then fine adjustments, automatic controls and improvements, even if frail, will undoubtedly be taken care of and prove good investments. If, however, the lathe is to go into the average shop, where it will be slighted and perhaps even abused, then simplicity of detail is very essential.

Speed-changing devices, other than electrical, if good, are very, very good; but if complicated, or not easy to get at and watch, they are apt to prove a nuisance and a source of considerable expense. This, of course, is not a condemnation of the variable-speed countershaft, of which there are a number of good ones on the market; but it stands to reason that if a variable speed is wanted, and the average kind is furnished, it is best to have it as easy to get at and watch as possible, for it undoubtedly does require a certain amount of watching.

FIG. 8. MOTOR TESTING ROOM

The single-belt drive, which is an adjunct of these variable-speed devices, is undoubtedly a neat arrangement and handy in many cases. It lends itself to the so-called convertible type of machine, that is, a machine that can be changed from a line-shaft drive to individual-motor drive, and also does away with the cone and shifting belt. This is apt to be of considerable advantage in a growing shop, but this advantage refers chiefly, of course, to types of lathes where the variation in speed is obtained between the driving belt and the work, and not where it is obtained in the countershaft.

Variable-speed motors somewhat overcome this difficulty, however, where some of the speed changes are in the bed of the lathe and a quite efficient drive results, provided one is willing to pay the difference between variable-speed and constant-speed motors and allow for the additional room required.

The quick-change feed gear is undoubtedly here to stay and the chief points to be looked at here are simplicity, strength and range.

No detailed reference has been made to live head, carriage or tailstock, and it hardly seems necessary if the general lines laid down are followed properly; and, furthermore, there are so many different types on the market that an article of this sort cannot deal fairly with them except in the most general way.

When the order is placed, there should be a most thorough understanding between all concerned as to what is to be furnished, and this should be in writing, even seemingly minor points being apt to cause trouble later on, unless this is the case.

Finally, and as a summary, the purchaser should know to the fullest possible extent what he is getting and what he can do with what he gets, and the manufacturer must know what he is expected to furnish.

Plans for Big Drydock

The largest drydock in the world, with a stone and concrete basin big enough to hold any two of the battleships of the United States navy at one time, is about to be constructed at Hunter's Point by the San Francisco Dry Dock Company at a cost of $1,250,000. The land has already been surveyed adjacent to the two docks that the company already has in operation, and the work will be rushed to a speedy completion.

It is understood that the work has been undertaken with the encouragement of the Navy Department, which is also said to have expressed a wish that it be carried to an early completion. It is said that the new dock will be 1050 feet in length, 170 feet longer than the famous dock at Glasgow, and 225 feet longer than the Alexandra dock in Belfast harbor.

Figures from a large alcohol distillery in Peoria, averaged for ten years show that the average price for corn was 42.36 cents per bushel, that the average yield was 4.76 proof gallons per bushel, and the average cost of manufacturing was 1.89 cents per proof gallon. This can be somewhat decreased by modern methods, so as to make the total cost 18.4 cents per wine gallon. Denatured with 10 per cent. of wood alcohol, at 40 cents a gallon, this makes a total cost of 20.5 cents per wine gallon.—*Dr. Leffmann, of Engineers' Club of Philadelphia.*

Even timber requires good air for its preservation. A poor atmosphere in a mine has been known to rot 12-inch Oregon pine in six to eight weeks.

The Washington Naval Gun Factory—X

Miscellaneous Points of Interest in the Navy Yard: New Electrical Generating Plant, Museum, Propeller-planing Machine, etc.

BY H. J. KENNEDY

Since January, 1906, electric current for power and light has been furnished by the new generating plant, which is one of the latest improvements in the navy yard and is located in the western addition to the yard. The two buildings—the boiler house, and the engine and generator house—were built in 1904 and 1905 respectively; they are of brick with steel roof trusses. The boiler room, which is exterior of the boiler house is shown in Fig. 72, which is from a photograph looking northwesterly across slip No. 4, and shows the two radial brick chimney stacks, which also are very conspicuous in the middle of Fig. 1, behind the President's yacht.

At present coal is stored on the ground west of the boiler house and is handled by a locomotive steam crane with a long equipment can be used. The boiler house is equipped with electrically operated coal and ash-handling machinery. The coal is dumped from hopper cars on the track east of the boiler house into a hopper below the track, from which it is carried by the conveyor.

The engine and generator house is a short distance north of the boiler-house; as shown in Fig. 73, in which it appears in

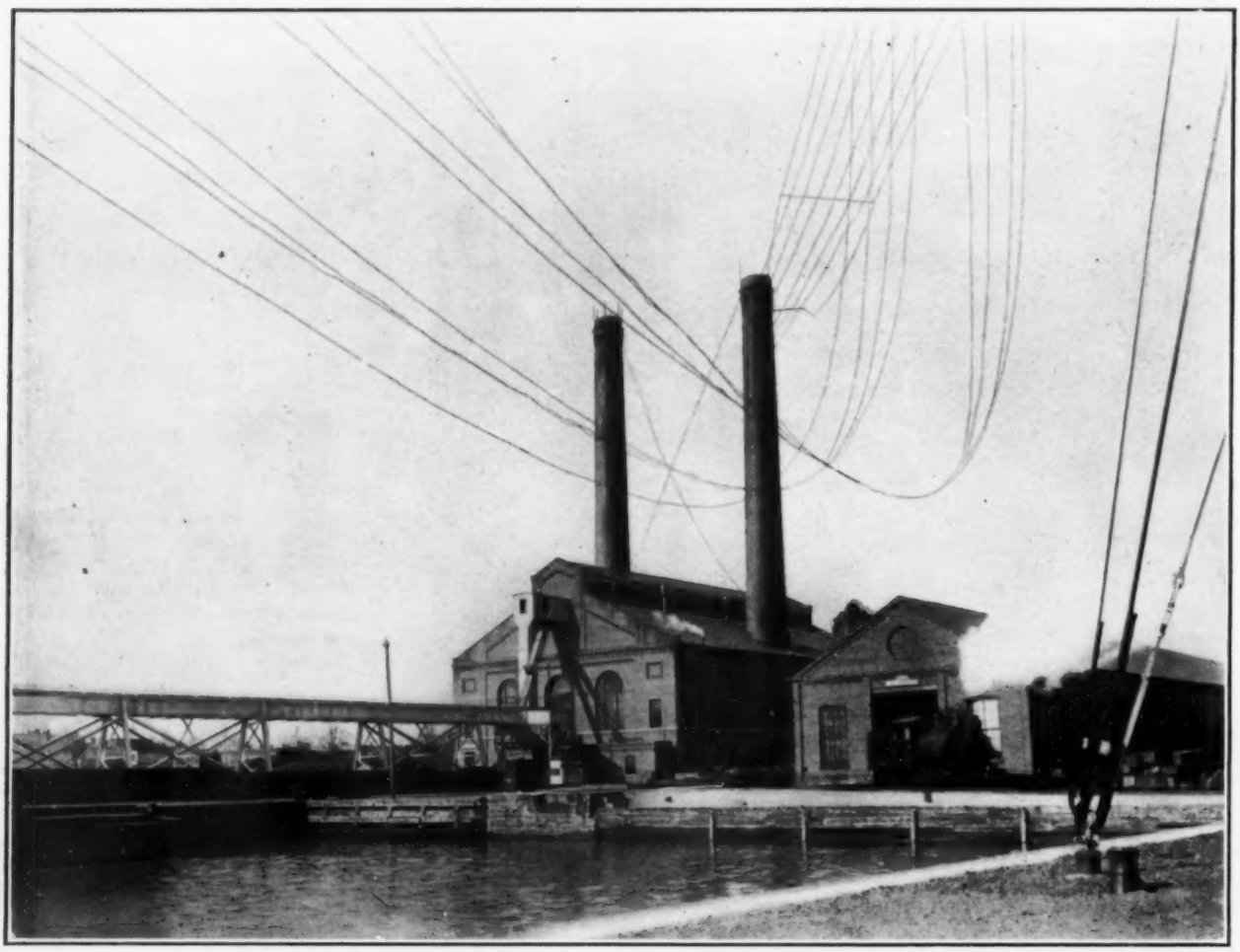


FIG. 72. BOILER HOUSE OF NEW POWER PLANT, AND GUN AND MOUNT STORE, FROM THE SOUTHEAST; ALSO RADIOTELEGRAPH ANTENNAE

the one farthest south, is 103 feet 3 inches by 165 feet 3 inches, and 46 feet high at the eaves. It will contain, when the equipment is completed, 20 Babcock & Wilcox water-tube boilers, 300 horsepower each, so that the aggregate boiler horse-power will be 6000. The boilers are equipped with automatic stokers, Green economizers, and superheaters. The last five boilers have yet to be installed. The boom; but provision is made for storage south of the house, and a steel trestle, seen in Fig. 72, has been erected upon which a traveling derrick is to run. The plan, Fig. 2, shows the outline of a building over this space, but the building has not yet been erected. It was found that the weight of the coal caused the made ground to settle, and it will be necessary to pile the floor before this part of the the foreground, it is a brick building of similar design, its dimensions being 101 feet 9 inches by 193 feet 9 inches, and 46 feet 6 inches high at the eaves, and it has, moreover, along its southern end an annex 70 feet long and 33 feet 6 inches high, for use as a repair shop. Along the east side of the engine room are ranged four Brown-Corliss vertical cross-compound condensing engines, each of which is of

1000 horse-power and is direct-connected to a General Electric 500-kilowatt direct-current generator, running at 120 revolutions per minute. These are type MP machines having 12 poles and developing an electromotive force of 240 volts. The engine room is roomy and well lighted, as may be seen from the interior view, Fig. 74. On the other side of the room some of the machinery from the old power-house is being installed, and it is probable one or more turbo-generators will be added before long. At the north end of the room is a fine marble switchboard, shown in Fig. 75, made by the Albert & J. M. Anderson Manufacturing Company, of Boston. The circuits are all protected by automatic circuit breakers. Near the switchboard there is a balancer set to take care of the variations in load on the three-wire system.

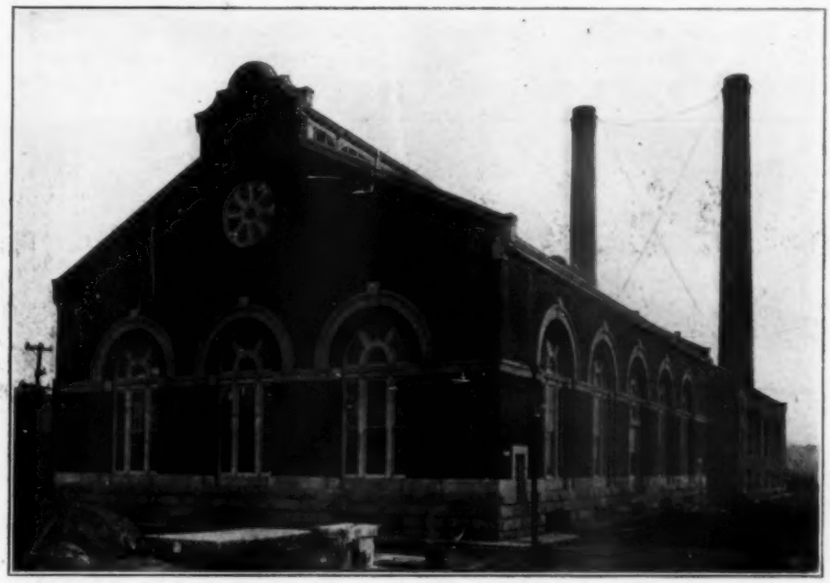


FIG. 73. THE ELECTRICAL GENERATING PLANT

The Radiotelegraph Station

In Fig. 72 will be noticed numerous overhead wires; these are the "antennæ" and connections of the wireless telegraph, or, to adopt the most up-to-date name, radiotelegraph. The mast is located between wharves Nos. 4 and 5, this station having early in 1906 superseded the experimental station. The location of the *old* mast is indicated on the map, Fig. 2, near the commandant's office. Near the lower right-hand corner of Fig. 72 can be seen some of the guys of the mast, anchored in an old gun buried in the ground. Between the two stacks of the power plant runs a cable which is too far off to be seen in the picture, but which shows in Fig. 73, and from the mast to the middle of this cable run the eight wires seen disappearing in the middle distance. From a point on the latter, midway between the mast and the chimney stacks, the wires are led off to the telegraph station, a small brick building not shown on the plan, Fig. 2, but located near the mast. From these "T-antennæ" are radiated through the air the Hertzian waves which

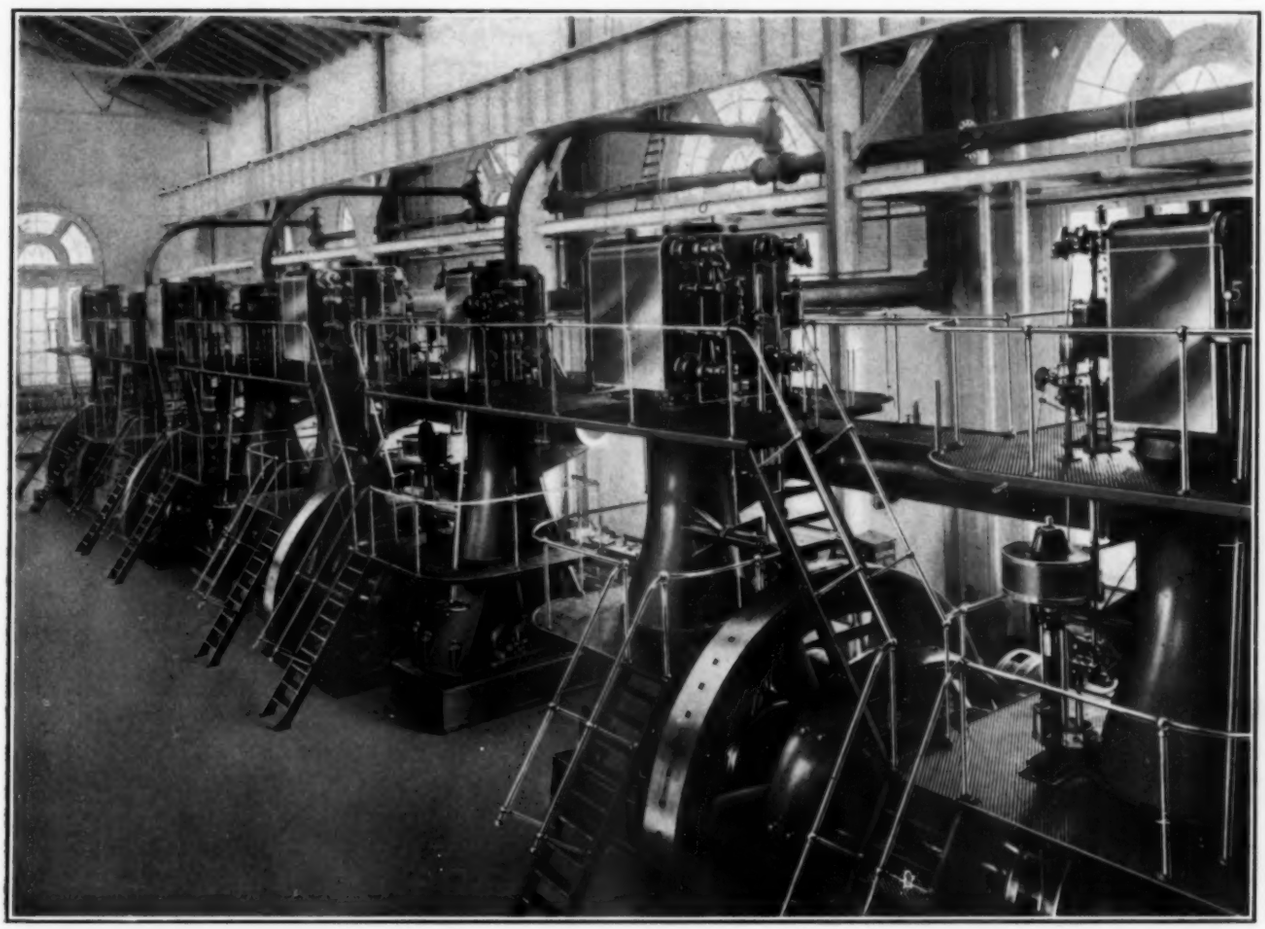


FIG. 74. INTERIOR OF ENGINE AND GENERATOR HOUSE

communicate with the naval vessels cruising within the zone of the Washington station. Daily communication is held with Cape Henlopen, and signals have been received from Quebec, Canada, and San Juan, P. R. Noon-time signals are sent out each day for the comparing of chronometers, the time being received by wire from the Naval Observatory. The station serves also as a medium of communication between the Weather Bureau of the Agricultural Department and the ships, sending out the storm warnings of the former and receiving meteorological observations from the latter. The Continental Morse code is used.

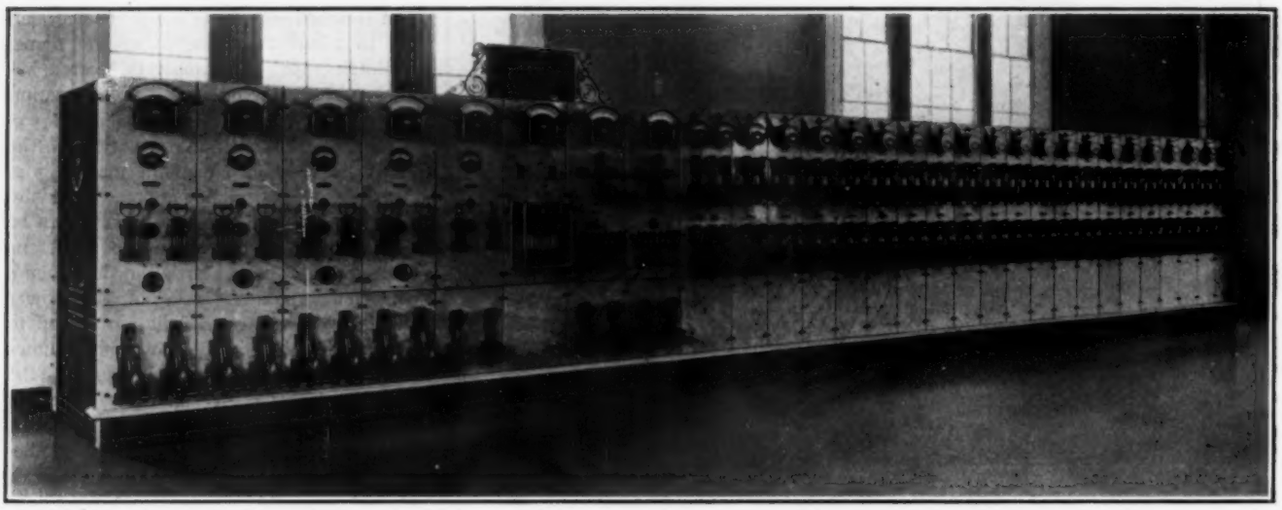


FIG. 75. SWITCHBOARD

The Gun and Mount Store

The storehouse for completed guns and mounts, which is located east of the power plant, and the south end of which shows in Fig. 72 back of the yard engine, was built in 1899 and lengthened in the following year, so that its length is now 492 feet 3 inches. The width is 55 feet 6 inches, the hight at the eaves 24 feet 6 inches, and the area 27,320 square feet.

The insecure nature of the ground has caused a difficulty to develop here similar to that in the case of the coal bin, a portion of the floor having sunk under the heavy loading. Though it usually contains a considerable variety of ordnance and ordnance stores, the visitor will derive small satisfaction if he enters it expecting to find an exposition, for he will find much of the stuff crated or boxed up, and the larger guns slushed and oiled, and minus most of their attachments.

The Museum

A sure-enough exposition, however, may be found on Warrington avenue, at the north end of Patterson avenue, in the museum building shown in Fig. 76, though it is an exposition of old-timers. This is an old two-story brick building about 30x60 feet, and it is full of relics of the past—old guns, projectiles, gun locks, rifles, sabers, curious inventions for army and navy, etc.—some even antedating the discovery of America, as, for instance, an old Spanish bronze gun of 1490, brought over by Cortez when he invaded Mexico in 1519. A contrivance which may perhaps be regarded as an ancestor of the breech-loading cartridge is a plug in which a charge is placed, and which is carried by a handle and lowered into an opening in the upper side of the barrel. There are many relics of the time of the Civil War; for instance, a Billingburst and Requa battery of 1862, which is a sort of substitute for a rank of soldiers; it consists of 25 gun barrels of 0.50 caliber placed close together side by side in a single plane; it was fired by a quick match extending right and left from the center. There is a ten-barrel Gatling gun of 1865; a two-inch revolving rifled cannon with six chambers (J. A. DeBrame's patent, 1861); a barrel about 3 feet long, with helical slots through the wall for about 26 inches of its length, with the object, it is said, of letting the air escape from in front of the projectile! There is a piece of the stern post of the U. S. S. "Kearsarge," and a 7-inch shell fired by the famous Confederate steamer "Alabama," during the engagement off Cherbourg, in

FIG. 76. THE MUSEUM

FIG. 77. CARTRIDGE-CASE FACTORY

FIG. 78. MODEL BOAT AT REST IN THE TOWING TANK; BOW VIEW

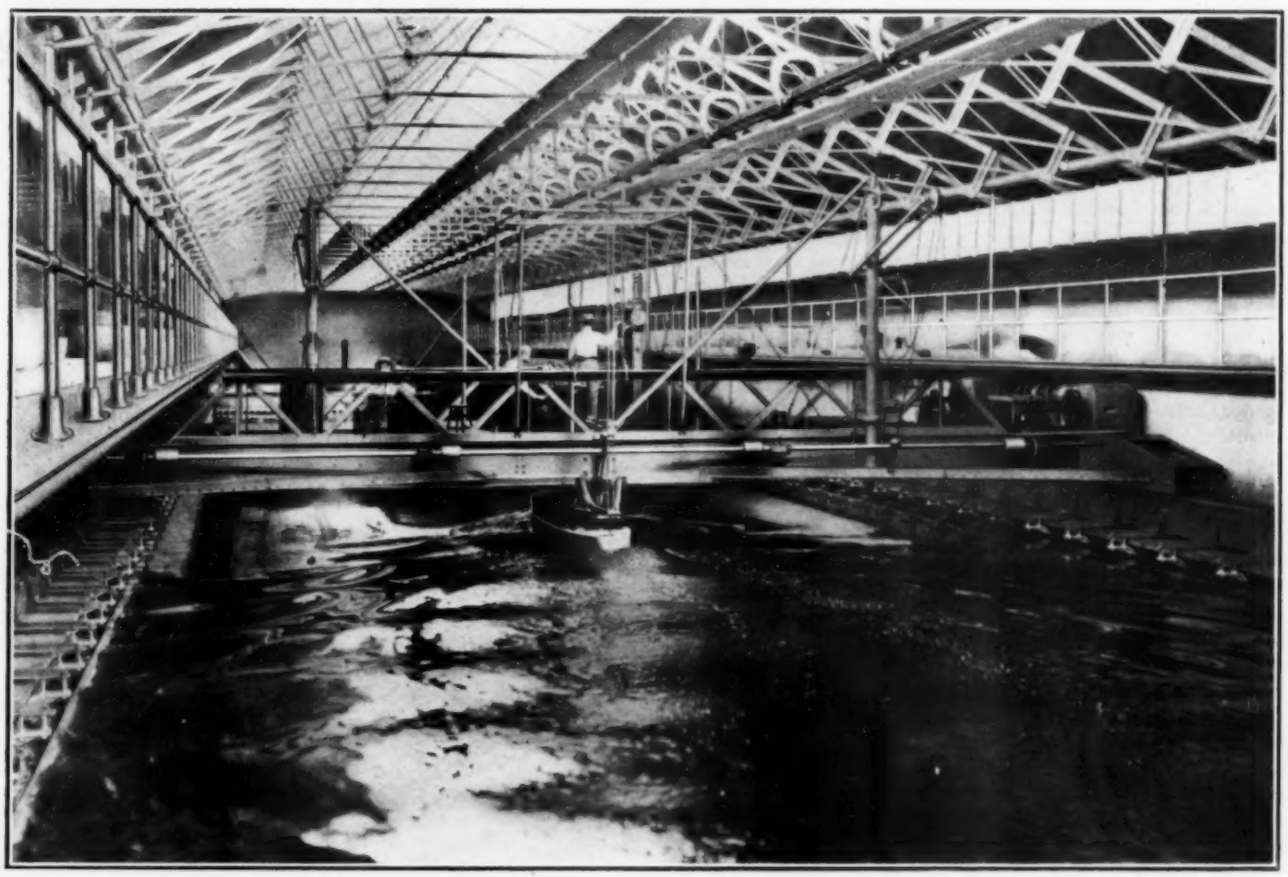


FIG. 79. MODEL BOAT IN MOTION IN THE TOWING TANK; STERN VIEW

which it was sunk, June 19, 1864. The shell weighed 55.75 pounds and carried a powder charge of 2.44 pounds. The Spanish-American War is of course also represented in the collection.

The Cartridge-case Factory

The cartridge-case factory occupies a small group of buildings east of the gun shop, the main building, shown in Fig. 77, being about 306x65 feet. There are also, in connection with it, a brass foundry, a boiler house (the chimney of which shows in the picture), and a house for the hydraulic-pressure pumps. The cartridge cases made here are for guns from 1-pounders up to 6-inch; the process of manufacture is similar to that described in the American Machinist, in the series of articles on the Frankfort arsenal, in the latter part of Vol. 28 and the early part of Vol. 29 (1905 and 1906). The slabs of brass are cast in the brass foundry, rolled and annealed, the scale removed on a machine, and the process of rolling and annealing repeated until the desired thinness has been attained. Blanks are then cut out, and are drawn up by successive operations to the form of the case, indented, cut off to length, headed, turned, gaged and stamped, and put in cases for shipment to the naval magazines. The larger presses are hydraulic, and the smaller ones are driven by electric motors.

The Experimental Model Basin

Though not connected with the manufacture of guns, the experimental model basin, which is operated by the Bureau of Construction and Repair, is an exceedingly interesting feature of the Washington navy yard; there is about it the attraction of the mechanical toy, of which it might be regarded as a gigantic and very pretty specimen, though in point of fact it is a scientific apparatus of very real value, which is the means of the saving of much money in the design of ships, and, in fact, has now become indispensable to the Government. Private ship-builders also are glad to make use of the tank when they can do so without interfering with the Government work. The building, which was built in 1897, is of brick on concrete foundations, 52 feet 5 inches by 503 feet, and 14 feet 8 inches high at the eaves, its area being 26,366 square feet. As previously stated, this plant was, in 1899, illustrated and described in the American Machinist, as well as the process of constructing and measuring the model boats, and the appliances used in this work; so it is superfluous to include the description in this article, but as no pictures of boats in the water were shown then, two or three such are given here. In Fig. 78 we have a bow view of a model boat at rest, while in Fig. 79 is a stern view of a boat in motion, in which the agitated surface of the water is in strong contrast to the placid appearance in Fig. 78. The motion of the bridge is regulated by the man standing up, with his left hand on the controller. It will be noticed that the bridge has been provided with cranes for handling the model boats. In Fig. 80 a model of the "Georgia" is shown traveling at an actual speed which represents a speed of 28 knots per hour on the battleship itself. The wave at the bow raised by this great speed is well shown. The ratio between the speed of the model and that of the vessel it represents is as the square roots of their lengths. As an instance of the results obtained, it was found, in the course of certain experiments, that a vessel of 4000 tons displacement and 350 feet long, required, in order to make 26 knots per hour, more than double the horse-power of a vessel of the same displacement, but made narrower and shallower and stretched to 450 feet in length.

Experiments with Screw Propellers

In addition to the great number of experiments which have been made in the tank as to the resistance of various models of hulls, some interesting experiments have been made under the direction of Naval Constructor Taylor, commencing in the summer of 1904, with model propellers, in order to determine their power and efficiency with various pitch ratios* and blade areas. In the first of these series of experiments 30 propellers were used, which were three-bladed, each one of them being of uniform pitch; various pitches were employed for the different screws, the pitch ratios extending as low as 0.4. The propellers were all 16 inches diameter, with pitches varying from 6.4 to 24 inches, so they were not toys, but appliances in a respectable proportion to the size and capacity of the towing-tank equipment; they were tested up to 150 pounds thrust. For each pitch five different widths of blade were tried.

Following the series of experiments just referred to, others were made in which were included 24 four-bladed, 9 two-bladed, 8 six-bladed, and 2 special three-bladed propellers, all of the same diameter, 16 inches, and of uniform pitch, and having, like the previous ones, varying pitches and widths of blade. This line of work is being still further continued.

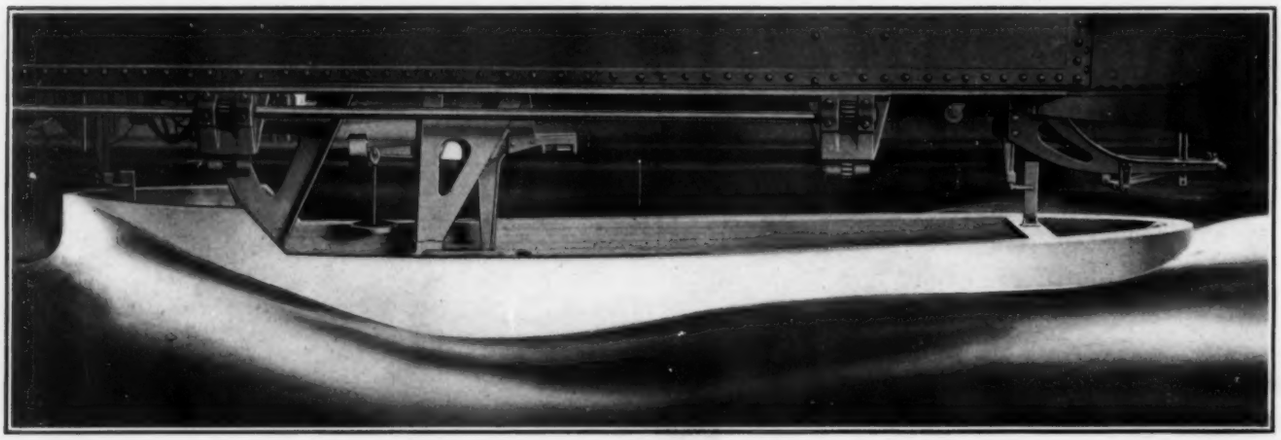


FIG. 80. BROADSIDE VIEW OF MODEL BOAT IN MOTION, SHOWING FORM OF WAVE

It is very apparent that scientific tests of this description demand great accuracy in the form of the models; for the construction of the propellers, as for that of the hull models, ample provision has been made. The propellers were cast in alloy, at first from wooden patterns, but afterward plaster of paris was found to offer greater facility and give good results as a pattern material. The face of the blade was finished in an interesting special machine, to be described a little later, and the rounded back was finished by hand, the final dressing being given to both surfaces by the use of emery cloth. The finish of the propellers is quite accurate; the blades are thin, the thickness at the root being 0.018 of the diameter, and at the tip 0.006.

The Screw-propeller Planing Machine

In the American Machinist, at page 83, an illustration and description were

* That is, $\frac{pitch}{diameter}$.

presented of an arrangement for planing the blades of a propeller; those who read about that rig will find it interesting to compare with it the very complete machine at the navy yard, which was designed primarily for finishing model propellers; there have also been made on it, however, a few electric-launch propellers, and some other miscellaneous small propellers—about 120 wheels in all. It will correctly machine the helicoidal faces of the blades of propellers, up to 26 inches diameter either two-, three- or four-bladed, and of either uniform or varying pitch.

FIG. 81. SIDE VIEW OF PROPELLER PLANING MACHINE

It may also be used for machining the backs of the blades, if so desired. The machine is located on the second floor of the Bureau of Construction and Repair shop, on the east side of the yard. It is illustrated herewith by three photographic views, Fig. 81 being the side opposite the driving belts, Figs. 82 and 83 being front views taken from different angles.

In this machine the helicoidal surface is generated by a combination of movements of the work and the tool. The work is supported on the horizontal circular platen or table, which is about 27 inches in diameter, and has a central stud, upon which the propeller is mounted, the outer ends of the blades being supported by adjustable supports bolted to the table. Above the propeller is the cutter head, which reciprocates up and down at the same time that the table with the propeller turns back and forth on a vertical axis. Both these motions are uniform, so that the result is to describe a helix on the surface of the blade. To produce a variable pitch, another motion is added, viz., the table itself is caused to move vertically by means of cams (not shown in the pictures) simultaneously with the other motions. The rolls which bear on these cam plates are, when in use, fixed under the ends of the two long arms seen sticking out horizontally from the periphery of the table.

Either of two cutter heads may be placed in the machine, one having four horizontal radial slots or channels, and the other three. The first, of course, is used for either two- or four-bladed screws. The one illustrated is for three-bladed screws. The vertical reciprocating motion is imparted through a forged-steel walking beam, the fulcrum of which (seen in Fig. 81) may be adjusted along a horizontal scale by means of the hand crank alongside the belt, in Fig. 83. As the back end of the walking beam has a constant amount of motion (8 inches), the vertical travel of the front end may therefore be fixed anywhere from 1 inch to 12 inches, giving a pitch of the screw propeller from 4 to 48 inches.

The crosshead at the back of the walking beam, seen at the left in Fig. 81, is not driven by a crank motion, as a harmonic motion would not be permissible, but is driven by a vertical lead screw on the end of the vertical shaft, showing plainly in the figure, with a large bevel gear on it, which is driven from a bevel pinion on the back-geared main driving-shaft of the machine. The whole machine is reversed in motion periodically just the same as a planer, by means of tight and loose pulleys, and open and crossed belts, so that the lead screw causes the nut and crosshead to travel alternately up and down. The connections at each end of the walking beam permit of sliding so as to allow for the motion of the ends in circular arcs.

The drive of the table is taken off the vertical shaft through one or other of the two bevel gears on its lower end, as determined by a clutch according to whether a right- or left-hand propeller is being made; the motion being transmitted to a horizontal shaft, a short portion of which may be seen in Fig. 83 between the up right and the circular base carrying the platen; a worm wheel under the table is driven by a worm on the front end of the shaft. The table, by means of adjustable dogs, actuates the belt-shifting mechanism, part of which appears in all the pictures, and which will be readily recognized by any machinist.

The crank in the immediate foreground of Fig. 83, and the pulley and gearing at the right, a little farther back, are for adjusting the position of the table vertically, either by hand or by power.

To return to the cutter head, in each of its three or four openings or channels is pivoted near the vertical axis of the machine a runway upon which a tool holder travels in or out radially. The outer end of this runway is clamped to the cutter head by bolts in the curved slots, so that it stands horizontally, ten degrees above, or ten degrees below the horizontal, or anywhere in between, enabling the cutting of propellers with the blades at right angles to the axis, or with rake, as may be desired. We have now two motions, viz., a reciprocating rotary motion of the platen, and a reciprocating vertical motion of the cutter head. The feed of the tool is produced by a movement of the tool holder along the runway, there being a feed screw to each tool holder and runway, all being connected together at the center through universal joints which permit of the varying inclination of the runways. A shaft extends horizontally on the cutter head toward the upright; close to the latter in the pictures may be seen a vertical splined shaft, on which is a bevel gear meshing with another on the horizontal shaft on the cutter head. This vertical feed shaft is driven by the mechanism down near the floor in the middle of Fig. 81.

In order to maintain the tool at the best cutting angle with the surface of the propeller blade as it travels over the varying inclination of the latter, the cutter head has attached to it diagonal guides formed of round rods which show very plainly in all the illustrations. The tool can swivel in the holder, and it is so placed that its point is in the axis about which it swivels. Then as the tool holder travels along the runway, the arm extending up and moving between two guides is compelled to swing and twist the tool holder, thus maintaining the proper angle of the tool with the work.

The machine is belt-driven from a countershaft by its own electric motor. It weighs about 12 tons and was built by the Builder's Iron Foundry, Providence, R. I. It takes from five to seven hours to finish accurately the faces of the blades of a propeller 20 inches in diameter.

Method of Conducting the Tests

The method of using these propellers in the experiments will be briefly outlined here. Instead of passing through the water astern of a boat, the propeller under test was mounted on the forward end of a long shaft extending about 8 feet ahead of a scow-shaped boat, the standard distance of the shaft center line below the surface of the water being one propeller diameter, or 16 inches. The boat was fastened below the towing carriage and was large enough to contain the dynamometer apparatus and an observer, though connections were made to the recording apparatus on the bridge or towing carriage, so that the autographic records of torque, thrust, etc., were made up there under the eyes of the party on the bridge. The propeller, while traveling forward through the water, was revolved by a 12-horse-power variable-speed electric motor on the bridge, a chain drive transmitting the power through a transmission dynamometer in the boat. Another part of the dynamometer apparatus gave a record of the pull exerted by the propeller. Speed and time records were also automatically produced, so that a complete record of the action of the screw was made on the traveling sheet of paper. The amount of slip can be determined much more accurately under these conditions

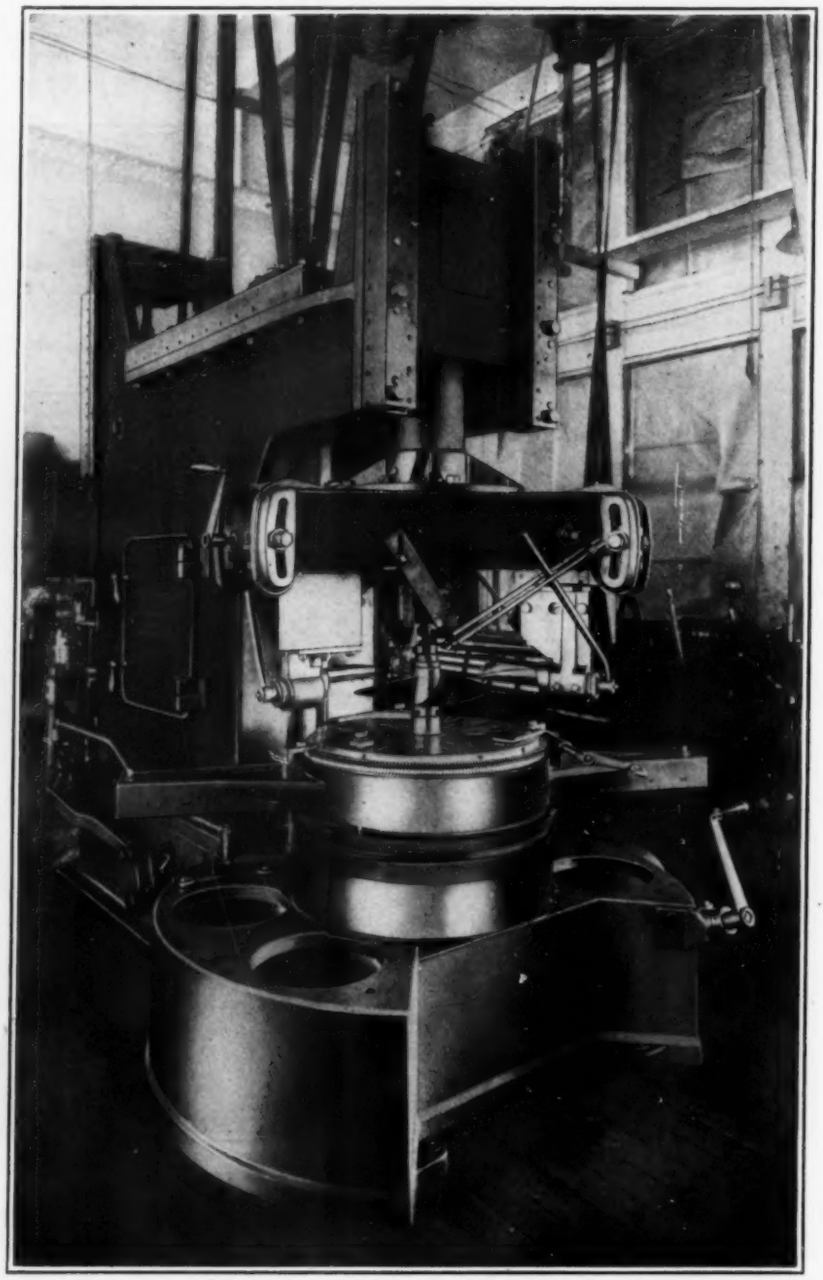


FIG. 82. PROPELLER PLANING MACHINE

than in the case of a screw propelling a ship. In the first set of experiments, tests were made at four, five, six and seven knots per hour speed of the carriage. It was found that within working limits the propeller forces varied as the square of the speed of advance, so in the second series a speed of five knots per hour was adopted for all runs.

Though the models do not afford any reliable index as to cavitation, the latter makes an interesting spectacle. When the propeller revolves fast enough to cause cavitation to occur, the disposition of the contained in the water are drawn out of solution to fill these spaces behind the blades.

Results

All that can be done here is to give a few slight hints as to the results arrived at by the tests. With three-bladed propellers the efficiency fell off steadily as the pitch decreased, showing that the highest maximum efficiency attainable occurs at a pitch ratio greater than 1.5*. With the four-blade wheels the highest maximum efficiency falls below the pitch ratio 1.5 for all but the widest blades. In the case of the two-bladed propellers, like that of the three-bladed, the maximum efficiency occurs at a pitch ratio greater than 1.5. A remarkably high efficiency, viz., 84 per cent., was obtained from a two-bladed propeller with a pitch ratio of 1.5, and a mean width ratio of 0.2. In the experiments, the thickness of the blade at the center was constant for all widths of blade, which, of course, is not exactly in accord with practice, and this, as well as the perfect finish of the propellers, perhaps accounts for some of the high efficiencies realized. It is likely, also, that the experiments made with these model propellers differ from the hull model-towing experiments in being not directly comparable to what may be expected from full-sized apparatus. This is particularly the case with respect to the occurrence of cavitation, the tendency for this phenomenon to occur being nothing like as strong with the model as with the corresponding full-sized propeller, because of the greater comparative submersion pressure on the former. Another point of difference is the fact that the full-sized screw is working in the wake of a ship in much agitated water, while the models are pushed forward in the undisturbed water of the basin. Nevertheless, these experiments afford an excellent means of comparing different designs. The subject of screw-propeller designing is complicated and vexatious, and anything tending to clear it up is gladly welcomed. As illustrating its importance, a certain foreign vessel, by a change of propellers, had her speed increased from 23 to 24 knots per hour, which denotes a vast increase in the amount of power *effectively realized*. Since the advent of the marine steam turbine and the consequent entirely new proportions of propellers, the demand for information has become still more urgent.

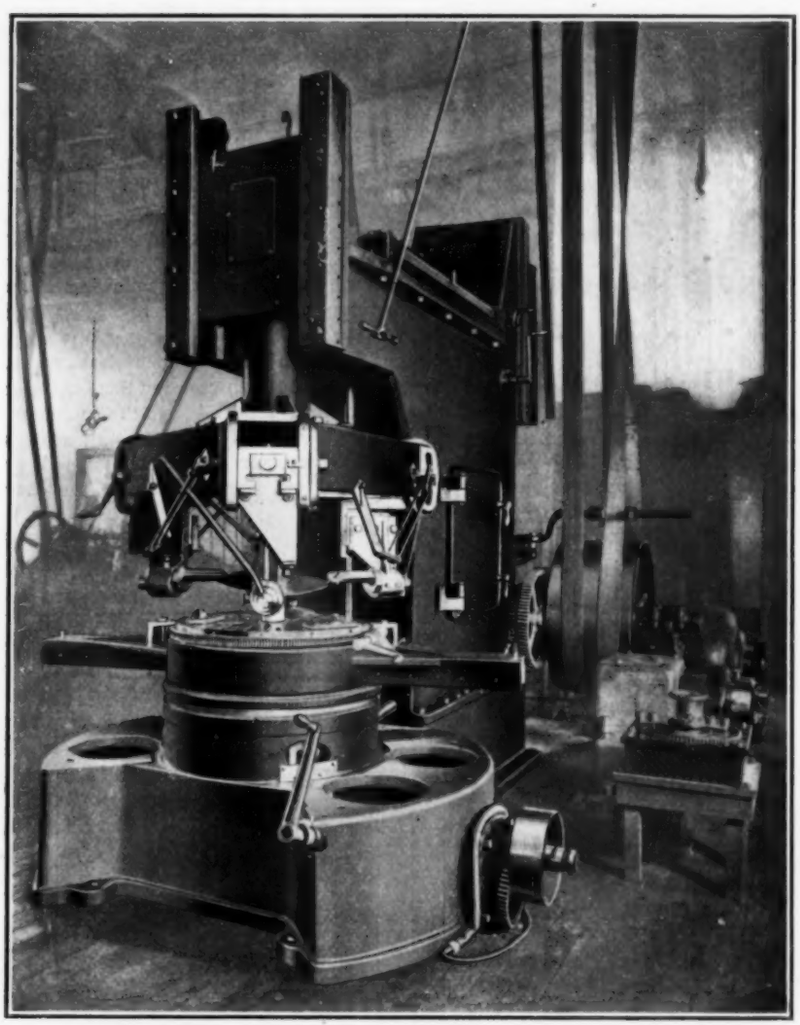


FIG. 83. PROPELLER-PLANING MACHINE

apparatus and the clear distilled water in the basin permit of a close observation of the phenomenon, impossible of course on an actual ship. When there is no cavitation, as ordinarily, the water over the propeller is clear, but as the speed increases the water becomes cloudy and the propeller is followed by a cylindrical stream of apparently milky water; the speed of the blade through the water being too rapid for the water to close in immediately behind it, there is a tendency to form a vacuum, and it is supposed that any gases (air, carbon dioxide, etc.) which may be

*Which, of course, means that the pitch is 1½ times the diameter.

The material aspects of the drafting rooms, chemical laboratory, offices and several minor shops in the navy yard do not enter into the scope of this series, which has already become somewhat lengthy, in the endeavor to give, as far as was practicable, an adequate general idea of the gun factory.

Pennsylvania Railroad and Steel Ties

It is announced that the steel cross-ties on the Pennsylvania Railroad at Mineral Point, Penn., where the fast "special" was derailed on Friday night, February 22, and fifty persons hurt, have been ordered removed and wooden ties put in their places. This is in consequence of the report of the committee sent by General Manager Atterbury to investigate the matter and ascertain the cause of the disaster. While the committee does not say that the steel ties were the cause of the accident it does say that if the ties had been of wood the damage to both passengers and train would have been less. The steel ties now in service will be relegated to one of the Pennsylvania's freight yards. An Associated Press despatch dated Philadelphia, says that General Manager Atterbury, of the Pennsylvania Railroad Company, has ordered the removal of all steel cross-ties now in use on the line of the Pennsylvania Railroad. —*Bulletin of the American Iron and Steel Association.*

Gear Ratios for Motor Drives

By W. Owen

One would have thought that as the subject of the graduation of gearing for a geometrically progressive series of speeds had been so thoroughly discussed in these columns, practically nothing new remained to be said regarding the matter. However, there are still one or two points of interest which have not, to my knowledge, received attention.

It is very often a point of difficulty, when dealing with combined motor and change gearing drives, to determine upon

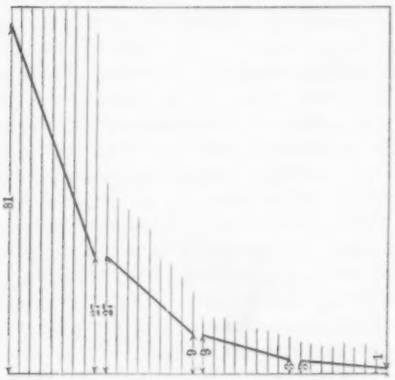


FIG. 1

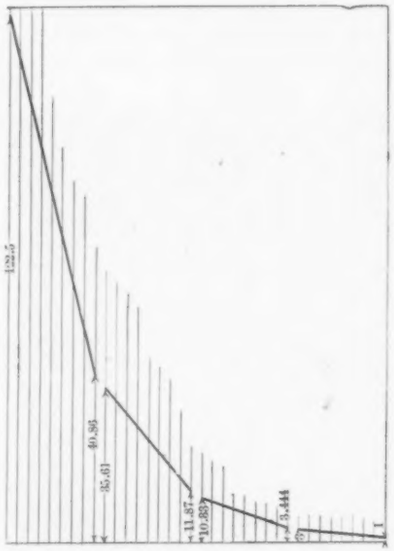


FIG. 2

GEAR RATIOS FOR MOTOR DRIVES

a suitable motor variation and ratio of change of gearing, after having settled the extreme spindle speeds. The method usually employed is to assume a motor variation, and to arrange the ratio of the change by gearing to advance in multiples of this quantity, increasing the number of changes until the desired speed ratio is obtained. This is an unmechanical process, and is only equaled by so designing cones and gears that the highest speed with the gear in is equal to the lowest speed with the gear out. A little consideration may be the means of saving one or even two pairs of gears, or, by retaining the same number of gears, increasing the total speed ratio.

The different speeds of a variable-speed motor are generally arranged in arithmetical progression, and, instead of advancing by a constant ratio, as in a cone drive, the increase is by increments of $\frac{S-s}{N-1}$, where S = highest motor speed, s = lowest motor speed, N = number of speeds on motor.

Now although there is this arithmetical progression to contend with throughout the motor range, there is no reason whatever why a geometrical advance should not be introduced between the gear changes, thus obtaining a maximum speed ratio with a minimum number of gears.

Were the speeds arranged in geometrical progression throughout the motor range, the ratio of advance would be

$$\sqrt[N-1]{\frac{S}{s}};$$

therefore this quantity will be the ratio of advance of the speeds between the gear changes. Thus we get:

Ratio of advance $= \sqrt[N-1]{\frac{S}{s}}$.

Ratio of first gear change $= \left(\sqrt[N-1]{\frac{S}{s}}\right)^{N}$.

Ratio of second gear change $= \left\{\left(\sqrt[N-1]{\frac{S}{s}}\right)^{N}\right\}^{2}$, etc.

Total speed ratio $= \left(\sqrt[N-1]{\frac{S}{s}}\right)^{(N\times G)-1}$,

where G = number of changes by gearing.

Total Speed Ratio.	Total Number of Speeds.	Ratio of Advance.	Motor Variation.	Number of Speeds on Motor.	Number of Changes by Gears.	Ratios of Gear Changes. 1st.	2nd.	3rd.	4th.	5th.
20.07	40	1.080	2	10	4	2.16	4.667	10.08		
20.7	36	1.090	2	9	4	2.18	4.753	10.36		
21.53	32	1.104	2	8	4	2.208	4.873	10.76		
22.53	28	1.122	2	7	4	2.244	5.035	11.30		
24.21	24	1.149	2	6	4	2.298	5.279	12.14		
26.84	20	1.190	2	5	4	2.380	5.665	13.48		
31.45	27	1.148	3	9	3	3.444	11.87			
31.96	16	1.260	2	4	4	2.520	6.351	16.01		
34.43	30	1.130	3	10	3	3.39	11.49			
36.84	24	1.169	3	8	3	3.507	12.3			
38.9	21	1.200	3	7	3	3.6	12.96			
41.86	18	1.247	3	6	3	3.741	14.0			
45.24	12	1.415	2	3	4	2.830	7.998	22.63		
46.65	15	1.316	3	5	3	3.948	15.59			
50.52	35	1.122	2	7	5	2.244	5.035	11.30	25.35	
56.1	12	1.442	3	4	3	4.326	18.72			
56.98	30	1.149	2	6	5	2.298	5.279	12.14	27.87	
63.8	25	1.190	2	5	5	2.38	5.665	13.48	32.09	
80.48	20	1.260	2	4	5	2.52	6.351	16.01	40.33	
80.91	9	1.732	3	3	3	5.196	27.07			
116.7	40	1.130	3	10	4	3.39	11.49	38.95		
121.9	36	1.148	3	9	4	3.444	11.87	40.86		
127.9	15	1.415	2	3	5	2.830	7.998	22.63	64.15	
127.9	36	1.149	2	6	6	2.298	5.279	12.14	27.87	64.04
129.1	32	1.169	3	8	4	3.507	12.3	43.15		
140.2	28	1.200	3	7	4	3.6	12.96	46.65		

TABLE OF GEAR CHANGES FOR MOTOR DRIVES.

As the motor variations generally used in this country are 2 and 3 to 1, it becomes a simple matter to calculate and tabulate the different speed ratios which can be obtained, and also the ratios of change of gearing necessary for the different numbers of speeds on the motors. The accompanying table, which I have compiled, is an embodiment of the foregoing, and will, I think, be found to be very useful.

A practical illustration of the advantage accruing from the use of the method here advocated is given in the two diagrams. In each case the drive is by means of a 3 to 1 motor, and 4 changes by gearing, but it will be seen that the total speed ratio is 50 per cent. greater in Fig. 2 than in Fig. 1.

It might be mentioned that the very small discrepancy between the total speed ratio as given in the table, and that on the diagram is due to the former being calculated as described, and the latter being arrived at by multiplying the lowest speed by 3, then again by the ratio of advance, and so on, thus allowing a small arithmetical inaccuracy to appear in the final result.

Although there is one less quantity tabulated in each case for the change gear ratio than signified by the number of changes by gearing, these statements are not at variance, as the ratio of first gear change is the actual ratio of the change between the first and second pairs of gears, etc., not the ratio of the first pair of gears, which, of course, is dependent upon the spindle speeds required.

Weaste, England.

In Germany the coke ovens are run more economically than in this country; considerable more care is taken to save the by-products, such as ammonium sulphate, a valuable fertilizer.

Sammy's Shop — Necessity Becomes the Mother of System

A foundry can't depend entirely on doing the odd jobs needed by the jobbing shop, and very few of the people who want castings have patterns to make them from; so whether you want to have it or not you will find that a pattern shop is part of the foundry, or, at least, Sammy, in his new shop, found that he had to have it that way. The first thing was grate bars. A jobbing molder can use a good casting for a pattern for a number of things. He can even use an old one for a pattern for some, and I have even seen him take a badly warped old casting and break it into pieces so that it would lie nearly flat on a board, and then use the pieces as a pattern; but I cannot recall ever seeing a molder rash enough to try to use even a new grate bar of the ordinary type used in boilers for a pattern, much less try it with an old one. Sammy found that there was a lot of grate-bar work to be gotten; but to get it he had to furnish the patterns, and the only way that he saw to do that was to make them, and if they were of a type in regular use he had to do it at his own expense.

The Pressure of Business

The first thing he knew he had a small and tender pattern shop on his hands. He did not want it. He would rather not have it, but circumstances seemed to force it on him. He began to find that business has a way of forcing a fellow when it once gets hold of him. He never thought of putting in a steam hammer when he started the blacksmith shop, but the jobs kept getting bigger, and it did not take him long to find out that the bigger and harder the job was to do, and the harder it was to find anyone who was willing to undertake it, the better the price that could be charged. Soon the blacksmith got into the habit of telling him how much bigger and better and quicker he could get out the work if he had a hammer. The idea stuck and in went the hammer.

Some Patternmakers

Along with patterns came flasks and wedges and "sogers," and a lot of other things necessary to the molder. Lots of folks said that Bill was only a "wood butcher," but after Sammy had tried some men who had the reputation of being first-class patternmakers, he got discouraged and got Bill. These first patternmakers were a nightmare to him. He had two, one after the other, who were very good men, indeed; that is to say, they were when they were sober, which was not often at the time he must have a pattern. Then he had one who was fairly good on a fine pattern, but was not able to make a cheap one. When this man undertook to make a flask Sammy had constantly to remind him that it was not a fine piece of furniture intended for the abode of wealth and luxury, but a contrivance for holding sand and standing the slugging of the molder, and of the man who took out the castings; and that if they did not demolish it it would get burned up. Even with hints of that kind, flasks made by him were expensive.

A Free-hearted Workman

One man did nice work, but very little of it, although to look at him one would say that he was a rapid workman. Judging by the explanations offered (during investigation), this was a wonderful man in view of his ability to work up scraps that could not be made into patterns, but which served nicely to make parts of toolboxes for the men. It would seem that he could do more work "noon times" on "government" work than he did during the rest of the day in working for Sammy. The men paid him for their boxes, but he was always very generous in giving away a board for a shelf or other purpose, and was never so busy that he could not plane it up and cut it to size, except during the noon hour. Such a free-hearted fellow, who was so generous with the shop men, could hardly be expected to discriminate against the pattern shop even if he was the only man working there, and Sammy had reason to think that something better than "scraps" went into work that he was doing for outside parties to his own profit, but not to that of the shop.

A Quick Job

This man, Bill (he was not the machinist) first came to work when some flasks were wanted in a hurry, and he got them out at a rate that was a surprise. The patternmaker at this time was one who had "business" which kept him away quite often, and then he had to lay off occasionally to "have these teeth attended to." One cannot be too critical of the breath of a man who is having to have his teeth fixed. He was away when a man came in and wanted to get a pump barrel. Bill offered to make it, and said that he could have it done in time for the day's heat. As the pump was part of the customer's steam engine, and was used to feed the boiler, he was tied up until the job was done, and Bill was told to go ahead. Sammy knew that it was, at least a two days' job to make the pattern and corebox, and besides that he doubted Bill's ability to make it at all. He was surprised to find the casting on the shop floor in the morning, and went to see the pattern. It was a one-casting pattern, and was made without any regard for durability, but the draft was all in the right direction, and the sizes were all right within the limits needed.

A Handy Employee

"There is no sense in taking a week to gouge out a trough and to turn up a couple of pieces and saw them off and nail them together, if a fellow knows what he is trying to do," said Bill. "You fetch any job around that you want done in wood and I'll do it, and I won't do it a bit better than you want it done, but I will do it good enough."

He was not as good on patterns which were wanted to last "forever," but as he could get out the regular kind very well, he was a very good man for the place and got out a lot of patterns. He seemed to enjoy doing the rough work, and would shingle the roof or build a shed as part of the regular work.

Pattern Storage

It was not Sammy's policy to make any more patterns for himself than he had to, and the first ones, when not in use, were hung up around the foundry on nails, wherever there chanced to be a safe spot. By and by they got too numerous for that, and some shelves were put up in one end of the room used for a pattern shop. They were laid on these shelves without regard to anything but the room to hold them. No record was kept of them, and when a customer came and wanted, say, a new crosshead for his engine, Sammy would take the old one and go and paw over the shelves and try to find a pattern that would make one near enough like it to be used. If he was not able to find one, he would go to Bill, and Bill would think that at some time he had made one "pretty near like it anyhow," and would look them over and then hunt through the foundry to see whether they did not have one or two patterns there. If unsuccessful still, the boss molder would look at the old casting, rub the side of his nose, scratch his head, borrow a chew of tobacco from Bill, call one of the cubs and quiz him, and then take a look around the walls and over the shelves.

The Lost Pattern Turns Up

Finally, as no pattern of the right shape could be found, they would conclude that they did not have any like it, and Bill would start in to "get up" one. In the meantime the cub would let his work stand and go poking around, and about the time Bill had worked the new pattern along to where it would not be good for anything else, he would dig out the pattern wanted from under a bottom board and a lot of gaggers. It would have a corner or two knocked off, and it would then be a question whether to finish the new pattern or repair the old one. It didn't do any good to get sarcastic about "people who can't mind anything from one day to another," but, such things happening often, have a depressing effect on the pocket-book of the "old man," and they made Sammy think.

Trying Systems

He didn't like red tape or anything of that sort, and had been used to carrying

the details of his business in his head, but he also wanted the business to grow and prosper. Little by little he found himself forced to put various systems in use. Some he planned himself, and some he saw in other places or heard about. The shelves for the patterns were numbered and divided into sections. Lists were made of all the patterns on hand and the place for them noted. All patterns not in active use or undergoing repairs were ordered put in their proper places. Now everything was lovely—for a time. There was one serious trouble. The system would not work itself. Sammy found that, while systems carefully planned and followed out were great time and money savers, somebody had to see that they were worked, and that somebody in his case was himself.

It took ordering, explaining, arguing, directing and "raising Cain," and lots of it, before any of his systems became even "semi-automatic." He didn't like to do these things, but it made him "wild" to see time and money being wasted for lack of them, so that gradually everything about the place was controlled by some kind of a system.

Some Up-hill Work

The more experience he had with the systems the more care he took in thinking out the details of a contemplated one and in trying to forecast its workings. If a system did not entirely fill the bill, and experience showed how it might be bettered, it was not an easy matter to make a change. After the men had been patiently and persistently drilled into a system until it got to be a fixed habit with them, it was often much harder to have them forget it and follow another plan than it had been to work them into the system in the first place. After some experience he concluded that it is a very poor system that is no better than no system at all, but he also concluded that it is hard to find a system so good that it can be mixed with a poor system and make a mixture that is better than the poor system without any adulteration. Besides that he found that he had so many places that needed "going after" that he did not have time and energy enough to train his force to more than one system for the same thing, unless the first one adopted had been outrageously bad, which it generally was not.

Opposition and its Effect

These things did not come about without opposition. Sometimes it was from the men. Sometimes it was from the foremen. Sometimes it was from the public. He got used to that after a while and it did not hurt as much as it did at first. It used to bother him to have a man throw up his job just as it did to have a customer take his work elsewhere, but he learned that, no matter what he did, he could not please everybody. He needed the machinist who thought making out a time sheet was "too much bookkeeping," and quit rather than do it, but did not see his way clear to get along without time sheets for all of that. After the happy-go-lucky way in which the shop used to be run it seemed rather severe to insist that a bright, intelligent young man be discharged just because it was seemingly impossible to have him get there until after the commencing whistle had blown, but he did not see how he could make one exception and not make more.

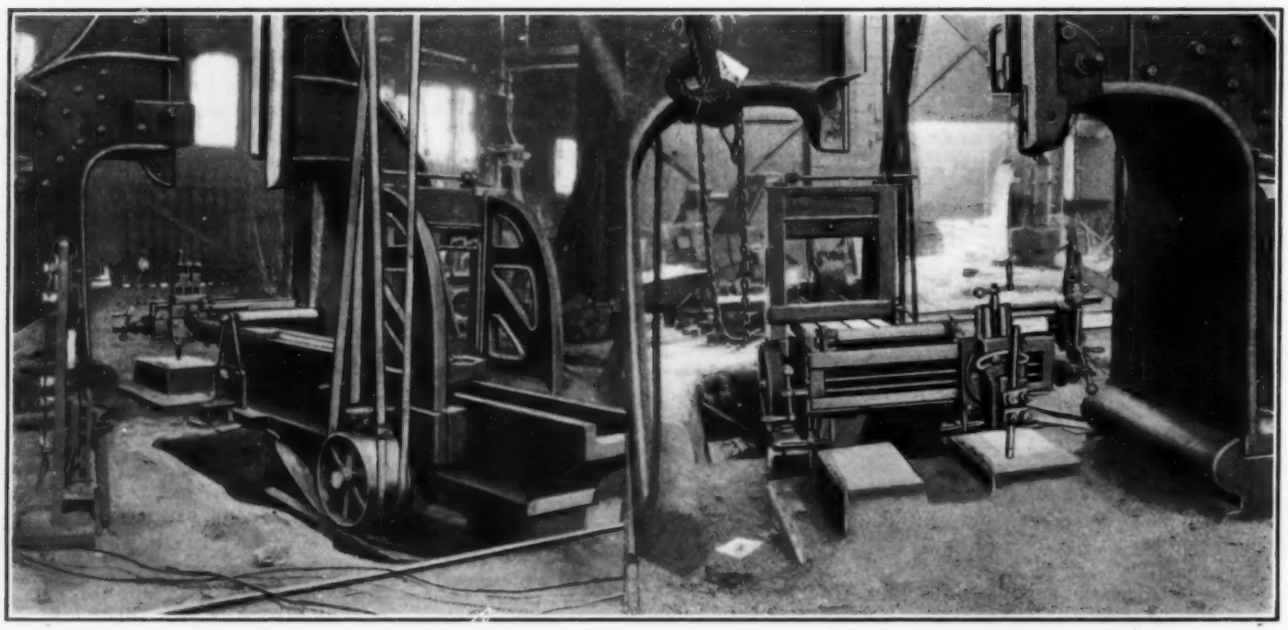
It was hard work sometimes to keep from reaching over a foreman's head to a man under him, but Sammy had to train himself to that; and before he got through with the job he found that he had more patience with the man whom it seemed to be hard to train into some of the shop systems. But for all the trouble that systems give him, he loves them for the trouble that they save him.

W. Osborne.

Planing the Anvil Block of a Large Steam Hammer

The two interesting photographs show how William Yates, the superintendent of the Heppenstall Forge and Knife Company, planed up the anvil block of one of their large steam hammers.

The anvil had worn out of shape so badly that it was necessary to plane off about 6 inches. So they took a 24x24-inch planer, moved it up to the hammer.



PLANING AN ANVIL BLOCK IN PLACE BY MOVING PLANER TO IT

fastened the cross rail to the end of the table with long angle plates, and went to work. The table was held down by the roller shown in both views, just back of the cross rail. The total time on the work was three days.

The photographs were sent by the secretary of the company, C. W. Heppenstall.

Dedication of the Carnegie Engineering Building

A preliminary announcement has been made of the dedicatory exercises of the Carnegie Engineering Building, which will take place during the week beginning April 15. The exercises will be very elaborate, and will form a fitting inauguration of Mr. Carnegie's great enterprise. Full particulars will be given out later.

Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

Quick Jigs for Small Auto Parts

Very recently, as I was passing through the factory, the foreman of the machine room stopped me and said: "Here's a jig that came down stairs from the tool room this morning, and it worked so slick that I just sat down and played with it for five or ten minutes. It almost seems to work itself; just a half turn of the thumb screw, and the piece is out, then another half turn and another piece is ready for the drill."

The jig in question was the one of which a sketch (Fig. 1) is shown herewith. There is nothing remarkable about it, except that it is a "quick jig," and serves to illustrate the point I am trying to make.

Too many tool designers lose sight of the fact that "time is money," and a jig that will save a man 15 seconds of time on every piece, in setting up for drilling say 5000 pieces (considering your drill-press hand at 17½ cents per hour), will save you $3.50 or more in actual cash on the job.

"But," you will say, "it costs probably nearly that much more to make the jig a quick one, so where do I gain anything?" This is not so. In the first place, a very little extra work is necessary, and a little extra thought, which after a while becomes almost second nature to a progressive designer. The extra cost of making the jig a "quick jig" in the majority of cases will not amount to 50 cents.

In automobile-jig designing, where jigs are to be used for from 1000 to 20,000, 30,000, or even as high as 60,000 pieces, the element of *first cost* of the making of the jig may be partially neglected, although judgment must in all cases be used, as to the number of pieces to be machined.

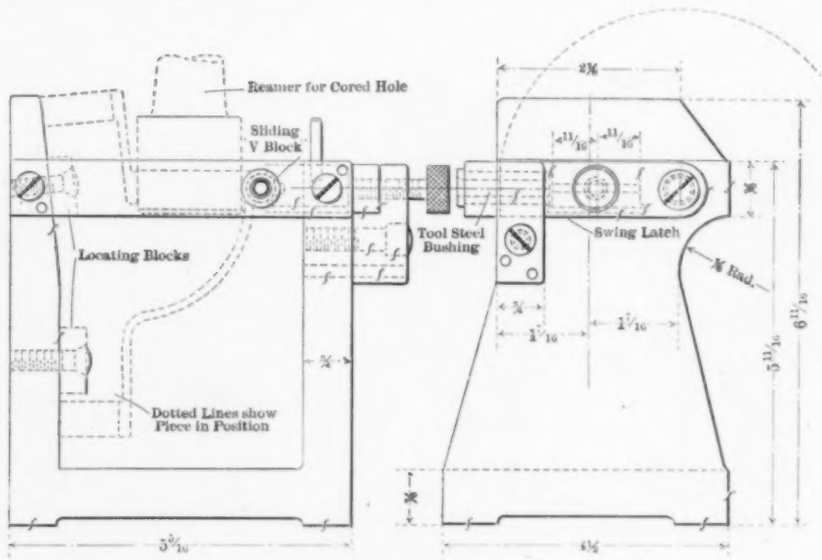


FIG. 1. SWINGING SET SCREW AND V-BLOCK CLAMP

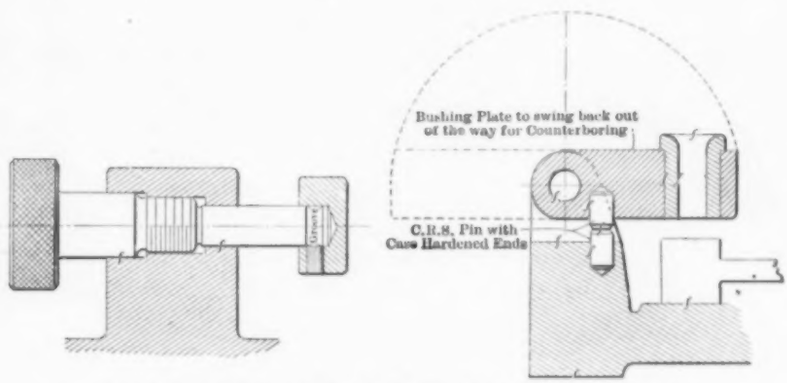
For instance, a six-cylinder car has six pistons. One thousand cars would require 6000 pistons. You can therefore afford to put more money into the first cost of a piston jig than into one for a carbureter or some other part of which only *one* will be used on a car.

Very frequently, in automobile work a year's trial of the part in actual road service will show points which may be improved, consequently the design of the part may be changed to suit. This will, of course, either require a new jig, or the old one must be fixed over to suit the new design of the piece. Where the change in the design is very radical, it will, of course, require a new jig, but in a great many cases the old one may be fixed over.

It is *always* advisable to allow generous clearances all around the piece. A half inch is none too much. Foundrymen are not any too particular in molding jig castings, nor are jig designers, as a rule, given to making allowance enough for variation in these castings. I have frequently seen jigs made with an allowance of ⅛ inch for a rough casting.

Inexperienced designers frequently make jigs and milling fixtures in such a way that they rapidly fill up with chips, and then after the jig has been used to drill half a dozen pieces, the man has to stop and clean out a little pocket or hole, or else his piece will not locate properly. All jigs, therefore, should be made as open as possible, so that they may be quickly cleaned.

Where a thumb screw is used close to a bushing, or in a milling fixture, a very excellent way to make it so that chips will not clog the screw is as shown in Fig. 2. If made like this, it is impossible for



FIGS. 2 AND 3. PROTECTED SET SCREW AND A HINGED JIG

chips to get in, because the screw is protected by the metal on each side.

Now, a thumb screw properly arranged is a very excellent thing; but there are numerous cases where it will force the piece out of position when tightening up unless provided with a revolving cap, as shown in Fig. 2. Here the cap is loose on the end of the screw and simply prevented from pulling off by means of a pin and a corresponding groove in the end of the screw.

It is very important to locate a piece

quickly and positively, and there is no better way known to me than the use of various forms of V blocks. These V blocks may be used at the same time for securing the piece firmly in its place without the need of other clamps or screws. See Fig. 1, where a V block is used for locating and also for taking nearly the whole thrust of the drill in two different positions.

In malleable-iron castings there is usually a great degree of variation which must be taken care of in some way. Take a lever, for instance, with a boss on each end; there may be a variation of ⅛ inch in the center to center distance of these bosses. There is nothing which looks much worse than to see a hole in a boss drilled off center, as it would certainly be in a case of this kind unless proper provision were made for variation. But, if we use one fixed V block and one sliding, then when our holes are drilled they will center up on the bosses as nicely as

brains in his work, and therefore you must endeavor to so design your jig that *he can't get it wrong if he tries.* In other words, *put in the brains at your end of the job.*

In all kinds of jig work we have occasion to force a piece into a certain position by means of a thumb screw, and in many cases where we chase up a sliding V block, we must back it out of the way to get the piece out. Turning the thumb screw around a half a dozen times is a very slow way to do. Arrange your thumb screw in a hinged latch, as shown in Fig. 1. Then you can give a half turn to the screw, throw back your latch and back the V block out of the way. Occasionally a cam, made by turning a piece of round stock ¼ inch or so off center, may be used where the piece is not apt to vary in size.

A point which is sometimes neglected is that of bur clearance where a drill runs through and of course throws up a bur

drill size and turned back out of the way for tapping out the hole.

Cold-rolled steel pins hardened on the ends may be driven into the bushing plate and casting, so that the plate will come down into place positively without the interference of chips.

In concluding this article I will say *don't make jig castings too light.* Never use less than ½ inch for even the lightest jigs, and use ⅝ to ¾ rather than make them too light. An extra pound or two of cast iron doesn't cost much, and it stays down better on the press and doesn't wabble around so much. Also you can throw it across the room if you want to (as long as you don't hit the foreman), and it won't be a wreck when you pick it up.

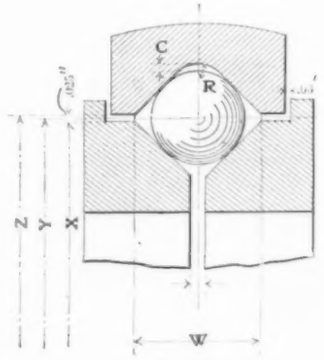
ALBERT A. DOWD.

Four-point Ball-bearing Data

The accompanying table of data regarding four-point ball bearings is a copy

DIMENSIONS
FOR
FOUR POINT BEARINGS

Diameter of Balls	.25"			.3125"			.375"			.4375"			.50"		
No. of Balls	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
8	.64	.695	.69	.80	.825	.85	.96	.985	1.01	1.13	1.155	1.18	1.29	1.315	1.34
9	.72	.745	.77	.90	.925	.95	1.08	1.105	1.13	1.27	1.295	1.32	1.45	1.475	1.49
10	.81	.825	.85	1.00	1.025	1.05	1.20	1.225	1.25	1.40	1.425	1.45	1.61	1.635	1.66
11	.88	.905	.93	1.10	1.125	1.15	1.32	1.345	1.37	1.54	1.565	1.59	1.76	1.785	1.81
12	.96	.985	1.01	1.20	1.225	1.25	1.44	1.465	1.49	1.68	1.705	1.73	1.92	1.945	1.97
13	1.04	1.065	1.09	1.30	1.325	1.35	1.56	1.585	1.61	1.82	1.845	1.87	2.08	2.105	2.13
14	1.12	1.145	1.17	1.40	1.425	1.45	1.68	1.705	1.73	1.96	1.985	2.10	2.24	2.265	2.29
15	1.20	1.225	1.25	1.50	1.525	1.55	1.80	1.825	1.85	2.10	2.125	2.15	2.40	2.425	2.45
16	1.28	1.305	1.33	1.60	1.625	1.65	1.92	1.945	1.97	2.24	2.265	2.29	2.56	2.585	2.61
17	1.36	1.385	1.41	1.70	1.725	1.75	2.04	2.065	2.09	2.38	2.405	2.43	2.72	2.745	2.77
18	1.44	1.465	1.49	1.80	1.825	1.85	2.16	2.185	2.21	2.51	2.535	2.56	2.87	2.895	2.92
19	1.52	1.545	1.57	1.90	1.925	1.95	2.28	2.305	2.33	2.65	2.675	2.70	3.03	3.055	3.08
20	1.60	1.625	1.65	2.00	2.025	2.05	2.40	2.425	2.45	2.79	2.815	2.84	3.19	3.215	3.24
21	1.68	1.705	1.73	2.10	2.125	2.15	2.52	2.545	2.57	2.93	2.955	2.98	3.35	3.375	3.40
22	1.76	1.785	1.81	2.20	2.225	2.25	2.64	2.665	2.69	3.07	3.095	3.12	3.51	3.535	3.56
23	1.84	1.865	1.89	2.30	2.325	2.35	2.76	2.785	2.81	3.21	3.235	3.26	3.67	3.695	3.72
24	1.92	1.945	1.97	2.40	2.425	2.45	2.88	2.905	2.93	3.35	3.375	3.40	3.83	3.855	3.88
25	2.00	2.025	2.05	2.50	2.525	2.55	3.00	3.025	3.05	3.49	3.515	3.54	3.99	4.015	4.04
26	2.08	2.105	2.13	2.60	2.625	2.65	3.12	3.145	3.17	3.63	3.655	3.68	4.15	4.175	4.20
27	2.16	2.185	2.21	2.70	2.725	2.75	3.24	3.265	3.29	3.77	3.795	3.82	4.31	4.335	4.36
28	2.24	2.265	2.29	2.80	2.825	2.85	3.36	3.385	3.41	3.91	3.935	3.96	4.47	4.495	4.52
29	2.32	2.345	2.37	2.90	2.925	2.95	3.48	3.505	3.53	4.05	4.075	4.10	4.63	4.655	4.68
30	2.40	2.425	2.45	3.00	3.025	3.05	3.60	3.625	3.65	4.19	4.215	4.24	4.79	4.815	4.84



Diameters

Diameter of Balls	W	R	C
.25"	.330	.06	.018
.3125"	.415	.10	.023
.375"	.505	.12	.028
.4375"	.595	.14	.033
.50"	.690	.16	.038

Above Dimensions are Given to nearest .005"

Dia. of Ball Circle $Y = \frac{D + .005"}{\sin \frac{180°}{N}}$ D = Dia. of Balls, N = No. of Balls

TABLES SHOWING CURRENT PRACTICE IN FOUR-POINT BALL BEARINGS

can be. However, the center to center distance will vary, and when this is *very important* (which is not usually the case) the bushings must be fixed and the V blocks simply used for locating.

In nearly all modern shops, the hands employed for drill-press and milling-machine work are foreigners, ranging in wages from $1.25 to $2 per day. Men of this class are more or less intelligent, as the case may be, but it is always safe to consider that the man who is to use a jig is a man who is not supposed to use much

so that it is difficult to remove the piece without the use of a hammer. If the piece in question slips on a stud, the stud should be cut away or grooved enough to allow for the bur in removing from the stud.

For small levers and bell cranks either of two methods may be used. A lid jig or a plain jig on very short legs, with bushing plates to turn back out of the way for counter-boring or tapping, is good, as shown in Fig. 3. For tapped holes, the bushing should be made tap-

of a formula and figures I found in the drafting office of the Garford Company, manufacturers of automobiles, in which I am employed. It represents current practice and should prove interesting to others.

ARTHUR B. HOWK.

Right and Wrong Way to Space Pulleys

Referring to an article on page 295, "Right and Wrong Way to Space Pulleys on Shaft," reproduced from a blue print

by Brown & Sharpe, I, of course, concur that Fig. 5 is right, but the loose pulley on the inside is wrong, for a number of reasons; you cannot oil them as well when on the inside; you require an extra collar; should the shaft wear, the loose pulley being on the inside, would necessitate furnishing a new shaft; however, should the loose pulley be next to the hanger, it can be turned and re-babbitted with very little expense.

HERMAN FLETCHER.

Pattern for an Automobile-engine Manifold

The drawing Fig. 1 shows an exhaust manifold for a four-cylinder automobile engine, and Fig. 2 illustrates the pattern and the core box used to cover the loose flange. In Fig. 3 the pattern is slightly separated to show the parting line, also the loose flange is slightly raised to show how it was made and a rib utilized to hold it from turning. In Fig. 4 the core box is separated to show the partings and the outline of the core. Fig. 5 shows the core box put together, and also how it was built up, and is an end view, the loose front being shown at *A*. The top is slightly raised to show more clearly that parting, and that a corner is cut away on which the strike *B* was used. It was necessary to do this and use a strike so that all parts of the core could be rammed, the core being made in one piece, avoiding pasted joints.

All the parts of the pattern were turned except the two inside curves that blend into the curve going into the upright as shown in Figs. 1 and 2. This was curved two ways and of necessity had to be cut by hand. The four prints were turned with the flange, and joined just back of it to the curve joining them to the straight part. This curve was turned by putting four segments on the face plate, the parting line being next to the face plate; two segments were used on each end of the pattern. The curve joining the two horizontal straight sections to the single pipe was turned in two rings of four segments each, the curved parting line being the outside diameter of the upper and the inside diameter of the lower. The joint on the face plate was in the center of the top and bottom ribs, or, in other words, the largest and smallest diameters of the ribs on the curves joining the straights to the single pipe. The handling of the single pipe will be plain without explanation.

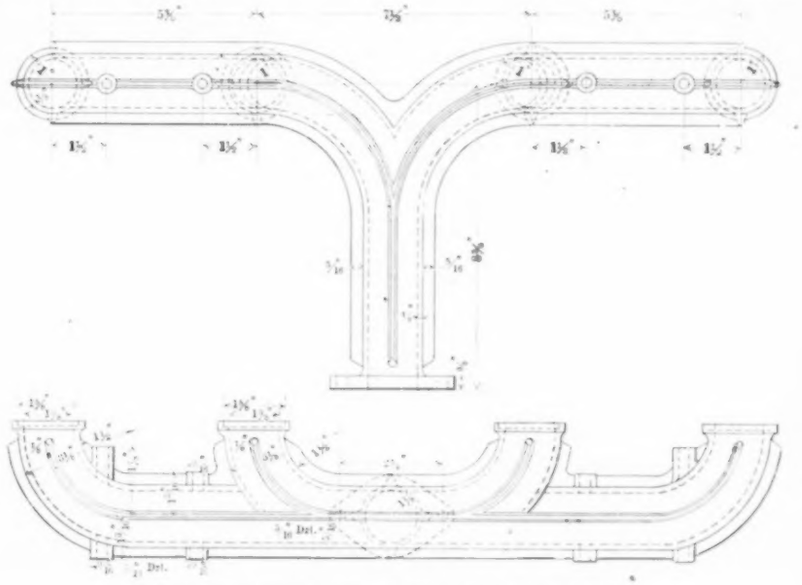


FIG. 1. EXHAUST MANIFOLD FOR AUTOMOBILE ENGINE

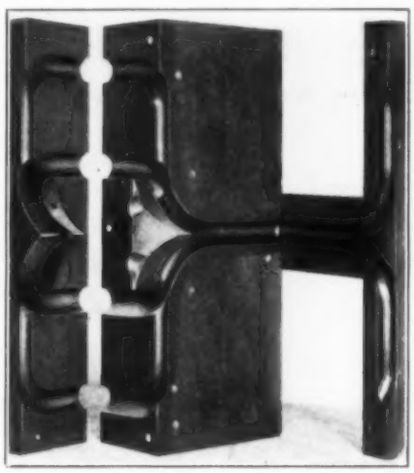


FIG. 4. THE CORE BOX OPEN

In assembling these parts a board was made with a hole through it so that the upward projecting curve of the cope half would drop through. Then by laying off the center line of the straight sections, the end curve and the four openings, it was easy to glue them together correctly. The drag half was then built on this half. The curved parting in the core box was fitted to the curve of the cope half of the pattern, and then the other half of the core box to the half first made.

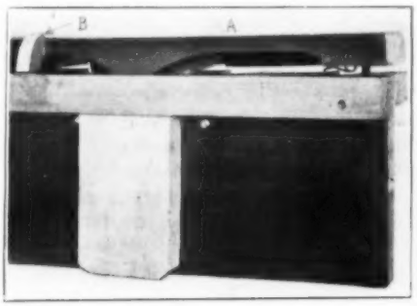


FIG. 5. THE CORE BOX CLOSED

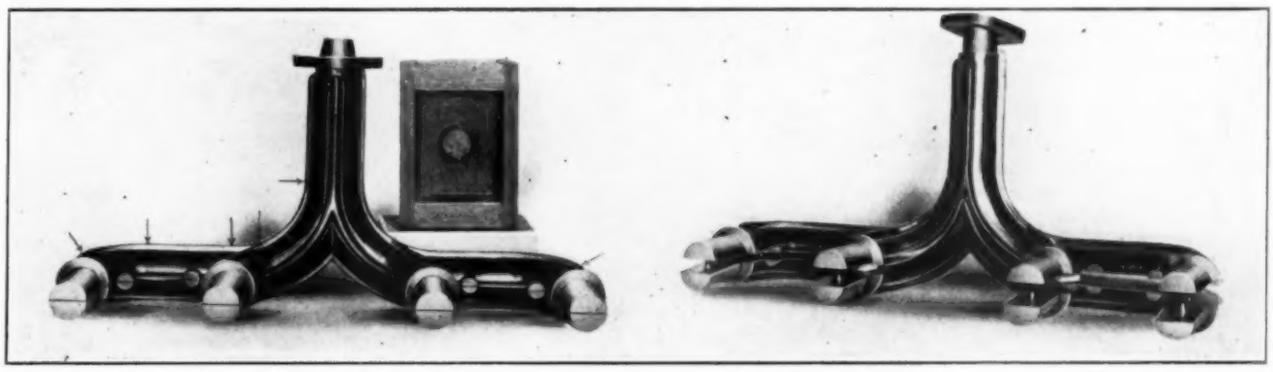


FIG. 2 FIG. 3

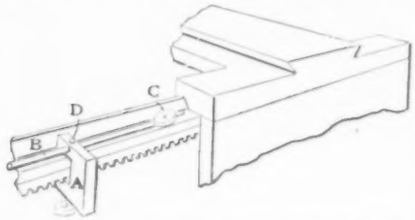
MANIFOLD PATTERN—ARROW HEADS SHOW LOCATION OF JOINTS

While this job looked difficult, it came out easy after the way was thought out. The job was made complete in 57 hours, and was good enough so that the first casting was good. Jobs that look hard are easy if only got at in the right way.

J. L. GARD.

Cutting Work to Length by Using a Dial Indicator

The illustration shows how I use a dial indicator to cut a number of pieces of work to the same length. *A* is a clamp drilled to receive the ½-inch rod *B*, on the end of which is mounted a Brown & Sharpe dial indicator. A small set screw *D* clamps the rod at the desired point.



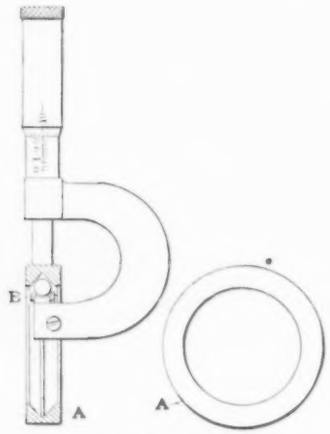
USE OF DIAL INDICATOR FOR DUPLICATING WORK

The first piece, having been measured to assure its being the correct length, is put in the chuck and the carriage moved along till the tool bears against the end. The clamp *A* is then set, and the rod *B*, with the dial *C* on the end of it, is moved along till the pointer on the dial makes one complete turn. The set screw *D* is then tightened. All subsequent pieces can be brought to length without trouble.

C. E. TANNER.

Sizing Ball Races with the Micrometer

Having recently a number of different size ball races to make in the lathe, and there being no gages or special tools for sizing them, I hit upon the following scheme, which may be of interest to some of the readers of the AMERICAN MACHINIST.



SIZING BALL RACES

The sketch shows a 1-inch micrometer and ball race *A*, the size of which is 2⅛ inches outside diameter; ¼-inch balls to be fitted to a 1¼-inch shaft. Over the anvil of the micrometer is placed a short shell *B*, which keeps the ball from rolling out of place. The difference between the outside diameter of the ball race and the shaft upon which it is used equals ⅞ inch. Therefore one-half of this, or 7/16, minus play or lost motion required, would equal the measurement of one side, as shown by sketch.

G. V. HUBER.

Pattern Plates for Split-pattern Machine Molding

Having had in my experience considerable difficulty with split-pattern plates on molding machines, and seeing a very easy way out of the trouble, I have prepared the accompanying sketches and description of methods of arranging these plates.

In Fig. 1, which is the usual type built, it will be noticed that it is necessary to have a center line on the pattern plate, and inasmuch as the mold depends for its center line on the flask pin, it is also necessary to maintain on the frame of the machine a center line, and these two center lines must absolutely match in order that there may be no shift in the casting.

In a foundry that has a number of machines of the same kind and also a large number of plates which are supposed to fit these machines indiscriminately, it is quite common to find a shift in castings and to trace it at once to these center lines not coming exactly in place. Now, the plates are always screwed to the machine, and after a while these screws become worn, as do also the tap holes in the machine, and there is a little play in them. In split-pattern work these shifts just double on the casting and it is always a matter that requires careful watching to avoid trouble.

In Fig. 2 we find the same style of plate used, with the exception that in this type it has been arranged to strip the pins, but, as in Fig. 1, it is necessary still to depend upon the matching of the center line on the plate with that on the machine frame in order that no shift may occur in the casting. In fact, this style of plate and machine is the same from a molder's standpoint, with the single exception that it strips the flask pins.

It will repay a great deal of thought and study on the part of those designing the pattern work and the molding machines if the job is so arranged that when completed it leaves no loop-hole for a mistake of any sort. As long as dependence must be placed upon center lines matching that soon become obliterated by wear, and that will vary a little on different machines, it leaves something to be watched by the superintendent, and even then there will be more or less bad castings from mis-matching, which can be avoided by a very simple arrangement.

It will be noticed in Fig. 3 that the fiask pin and hole are in the pattern plate itself, and not in the machine frame. Now, this hole and pin are used as a center line when putting the patterns on the plate, and, once properly located, nothing that may wear or get slightly out of order can make a shift in the castings. The molding machines may differ in the drilling, but it will not matter in the match of the castings. In other words, the same center line is used in making the mold as has been used in putting the patterns on the plate.

On split-pattern work which requires one plate for the cope and a different plate for the nowel, if these plates are first drilled for the flask pin and hole, then put face to face, and bolted securely together when they are drilled to receive the patterns, it is a sure thing that the cope and nowel will match up absolutely. If the plates are stripping plates, and they are treated in the same manner when receiving the final finish, they, too, must match.

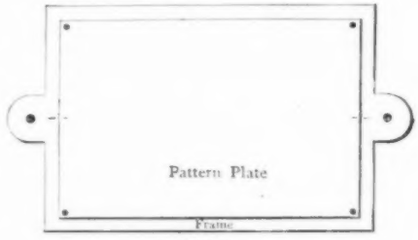


FIG. 1

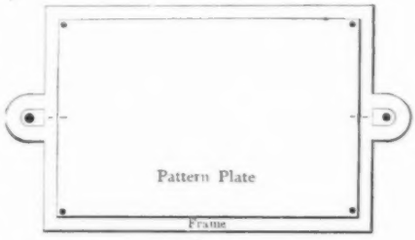


FIG. 2

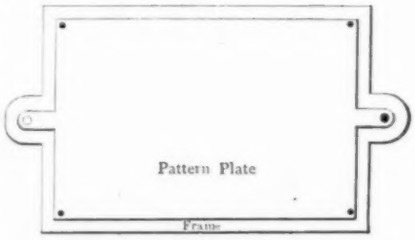


FIG. 3

PATTERN PLATES FOR SPLIT-PATTERN MACHINE MOLDING

Another little thing that makes things handier is, instead of having two pins in the drag flask and two holes in the cope flask, to have the machine plate with one pin and one hole, then each half flask has one pin and one hole. This makes it un-

necessary to keep in separate piles the cope and drag flasks, and where they are of the same depth, no matter what flask the operator gets hold of, he can use it at once. This is a small matter, but in molding-machine work even seconds count, when one is looking for the utmost limit of production.

W. C. WRIGHT.

Another Steam Trap

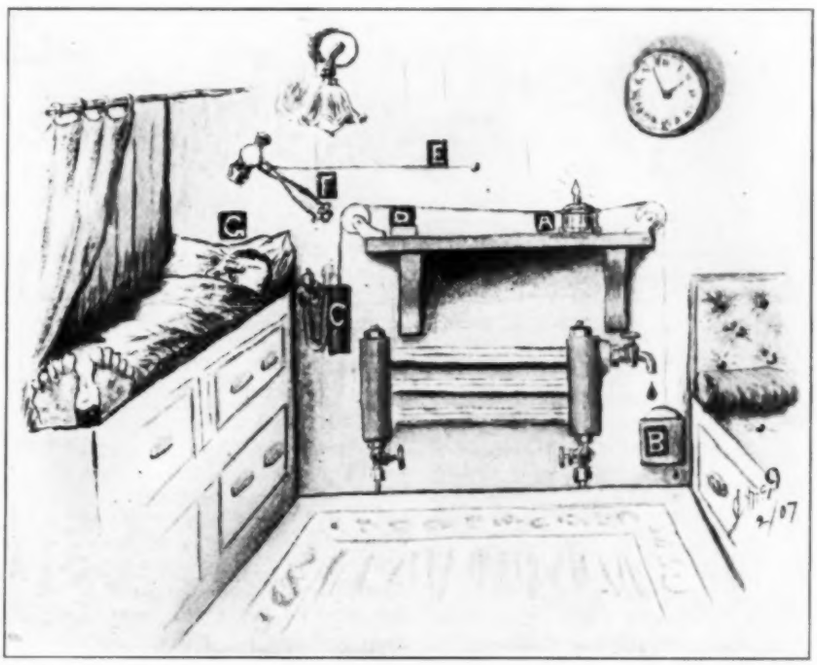
Having seen Dixie's account, at page 487, Vol. 29, Part 2, of how his chief engineer detected the stopping of the fans to save steam, I read it to the boys in the mess-room, and gave it as my opinion that it was a very ingenious contrivance.

Thereupon, Ananias, the third assistant, related a similar narrative about a chief with whom he had sailed. Like the engineers of Dixie's ship, they did everything possible to save steam and get revolutions, and one of the methods adopted during the night watches was to shut off the heaters, which were coils of pipe inclosed in large boxes through which the air was driven by electric fans, and which on a passenger ship *do* run away with a lot of steam. The apparatus, as seen in the sketch, consisted of a shelf at the ends of which were two pulleys, over which ran two cords, one end of each cord being attached to a small oil lamp *A* situated on the shelf near one end. The other ends of the cords suspended a weight and a tin can respectively. Under the shelf was the heater or radiator for the chief's room, on which there was a small drain cock that could be set to drip into the tin can *B*, which it kept about three-quarters full as there was a small hole in the botton, allowing the water to run or drip away.

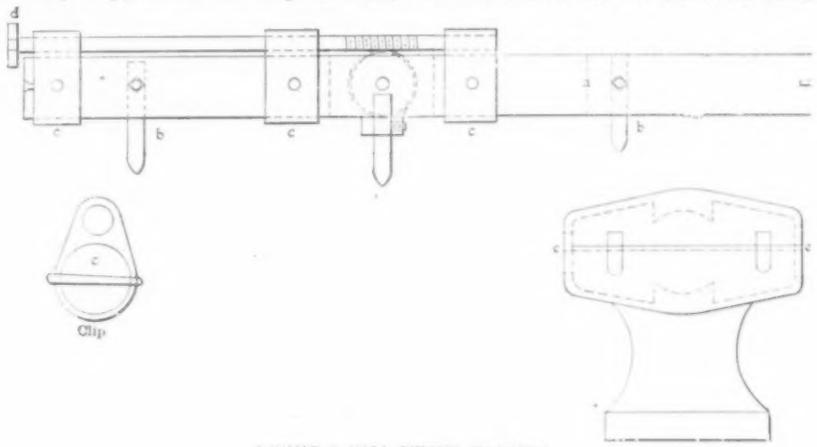
The moment the heaters were shut off the drip stopped, the can emptied itself, and the weight *C* overcoming the now empty can descended, dragging the lamp to the other end of the shelf against the stopper *D*, which brought the flame of the lamp against the cord at *E*. Burning it through released the hammer which (like the sword of Damocles) was suspended over the chief's head, and had a fulcrum on the electric lamp switch *F*. It struck the chief on the head *G* (ee whiz!), and at the same time switched on his light and rang the bell to the engine room. This put the chief in a frame of mind fit to discuss the subject fluently and forcibly with the victim who should answer the bell.

The idea is a very simple one, and one which it is not easy to "fake," and as it is not patented or protected in any way any brother engineer is welcome to profit by the idea and have it installed at practically no cost or trouble; for I have it from Ananias himself that it was never known to fail and could not be fixed with a little glue like Dixie's cigar box.

JAS. MCDONALD,
First Assistant Engineer,
S.S. "Samland."



ANOTHER STEAM TRAP



BORING A BALL-SWIVEL BEARING

Boring Ball-swivel Boxes

As we had occasion to build a number of ball-swivel boxes for a newly designed machine, the question arose as to the proper way to machine the ball socket. Our old boxes had always been made by pouring babbitt around a special arbor the exact shape of the bearing, and scraping to a seat. This new design called for a cast-iron seat, therefore it was necessary to machine the socket. As the cap and box were lipped together, it was necessary to machine the box after the cap and body were bolted together.

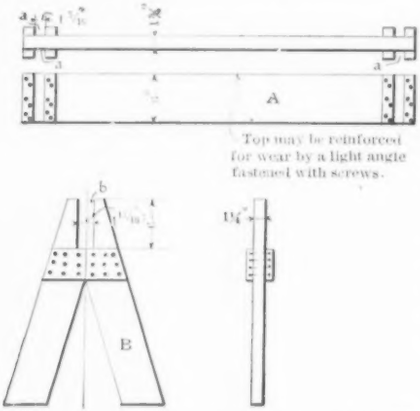
The first set was milled with a ball cutter by first roughing out both the cap and the box to within 1/32 inch, and finishing by bolting the cap and body around the cutter and slowly tightening the bolts, while the cutter revolved. This did the job after a fashion, but was a very slow and unsatisfactory way. Therefore a special boring bar was designed, which answered the purpose much better and did the job in a great deal less time. This bar was about 4 feet long by 2½ inches in diameter. A 5/8-inch slot milled in the center of the bar held the tool holder, which was really the worm wheel with teeth on one-half its circumference only.

This worm wheel was rotated in the slot by a feed rod with the worm cut directly on it. This rod was driven by a star feed wheel *d*. The cutter was a piece of high-speed steel which lay back along the shaft until the star feed caused it to describe an arc. The time for the star wheel to get busy was determined by an index line *a* appearing flush with the end of the box. The clearance diameter *e e* in the front and back end of the bearing was

provided for by the straight cutters *b* and *b*. The star feed bearings or clips which hold the feed screw to the bar are shown in detail and at *c c c*. TEXAS.

A Trestle Which May be "Knocked Down" for Storage

Herewith is a sketch of a trestle which may be readily taken down and stored away in some small corner of the shop. The top bar or rail *A* is provided with



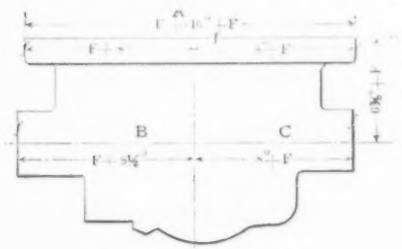
A TRESTLE WHICH MAY BE "KNOCKED DOWN" FOR STORAGE

grooves near each end, formed by nailing strips of wood on each side as shown at *a a a*. The legs, one of which is shown at *B*, has a space *b* at the top which is a pretty close fit over the top bar, and the strips on each side of the top bar are a close fit on the upper end of the legs. This trestle is not so useful in the machine shop, possibly, as in some other lines, but its collapsible feature is perhaps worthy of your attention. It is certain that the old form of trestle is a very unhandy contrivance to store away when not in use. W. E. MOREY.

St. Louis, Mo.

Stating Sizes Clearly for the Patternmaker

Herewith is a sketch or outline of a pattern that I made a short time ago



STATING SIZES CLEARLY

from a drawing made by a young mechanical engineer. I wish to call attention to his method for dimensions where finish is to be allowed on the pattern. I never saw this on a drawing before, but can assure draftsmen that this method is a great help to patternmakers and prevents many mistakes. This was a very intricate pattern to make, and the drawing was covered with dimension figures; but I have placed on this sketch a few figures only to explain the method.

You will notice that *Fin* is to be allowed on all the dimensions, and together with the character *f* is also added the sign + *F* before or after, as required. At *A* *F* + 16-inch + *F* shows finish on both ends. The patternmaker's attention is called to the finish when reading the dimension. At *B* the dimension is *F* + 8½ inches, calling attention to the end where the finish is to be allowed, and at *C* the reverse end, 8 inch + *F*.

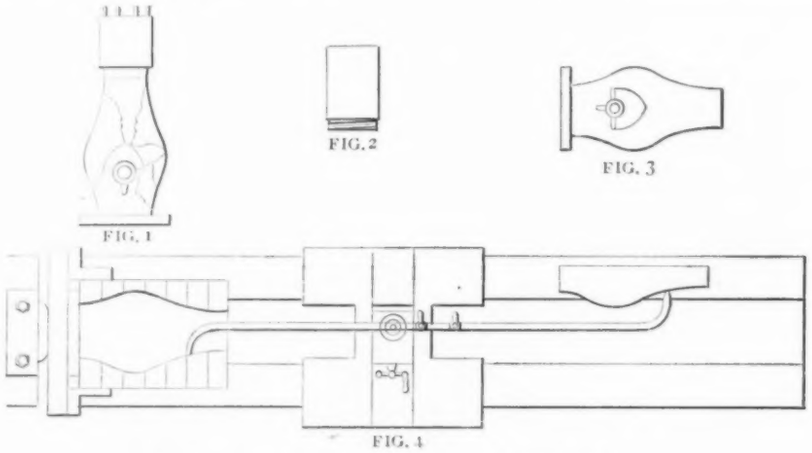
It is almost impossible to make a mistake with this method, while mistakes with the ordinary character *f* are common.

There is also a note on the drawing showing the amount to leave for finish and also the shrinkage to allow, thus: ⅛ inch rule, ⅛-inch finish. I am quite sure this method would be appreciated by patternmakers and machinists in general.

PATTERNMAKER.

Repairing a Gas Engine and Making a New Base

Perhaps the way I bored out a core box for a small gas engine is not new to all of your readers, but at the same time it may interest some others.



REPAIRING A GAS ENGINE—MAKING A CORE BOX

A 3-horse-power gas engine came to us with the base broken, something as in Fig. 1. It was a 4-cycle type, open in the base on each side over bearings. The cylinder and base were cast in one piece and patching it was out of the question, as it was too badly broken. The only way out of it was to cast a new base, so we put the cylinder in the lathe and cut it off, as in dotted lines in Fig. 1, trued the end and cut a thread on it, as in Fig. 2. Then we screwed the new base on good and tight and put in a couple of set screws to make a surer job of it. The little engine has been running constantly since, with no signs of loosening up.

MAKING THE NEW BASE

You know how it is in a repair shop where the lathe hands have to turn patterns for the patternmaker who has no wood lathe. Well, the pattern and core box were given me to be turned; the pattern, as in Fig. 3, was easy, but all the while I had the core box in mind; I schemed a way that turned out better than I expected.

The core box had to be ⅜ inch on a side smaller than the pattern, with the same curves, so as to have an even amount of metal all around. I got the patternmaker to make me a templet of the core box as it should be when finished, as shown at *T*, Fig. 4. I chucked and clamped the pattern in the lathe, as shown, and of course bolted weights on the chuck to counterbalance the pattern. I then made a long offset boring tool, clamped it in the tool post with the cutting point in direct line with the centers of the lathe.

FOLLOWING THE OUTLINE

On the back end of the boring tool I clamped a piece of ⅜ round iron that had one end bent and pointed. The templet was then nailed to an upright piece that I had fastened to a board and clamped to the lathe bed. I tried the templet with the back and front of the core box; also had it at the same hight as the centers of the lathe. On the first and second cuts I had to let the pointer travel at a little distance away from the templet, but on the finishing cut I just kept the point from touching it. The finished job was barely 1/16 inch out and was very satisfactory in every way. I have done other jobs using the same kind of rig, and was always successful. YRDNAL.

The earliest authentic instance of a windmill in England was one at Bury St. Edmunds in 1194.

Practical Testing of Rubber

By Centrode

This material in the form of sheeting, valves, etc., occupies an important place in the materials, odd and otherwise, that the present-day machinist and engineer are called upon to use. Its price—which rises steadily year by year—does little to deter its rapidly extending use, as no efficient substitute has been found having the peculiar characteristics it possesses; wide application is probably the principal factor enhancing the price. The methods of collection are primitive, and the supply cannot keep pace with the demand.

The finest gum—known as Para—is so high in price that it is increasingly difficult to obtain manufactured material having this gum as its elastic ingredient. Makers tend to use a proportion of remanufactured material, which is never so satisfactory as the South American gum, and should consequently be rigidly barred, where rubber has important duties to fulfil.

Compositions differing in their constituents, all known as rubber, are satisfactory when used for the particular purpose for which they have been made. But good results cannot be looked for unless first-hand rubber is used, as a large per centage of the whole. As these formulas of composition concern the actual makers more than the users, they are omitted. But a test to which all kinds of good class rubber can be subjected is available to the possessor of some easily constructed apparatus. The test is applicable to any rubber, whether partly combined with canvas or without.

The Apparatus Used

Referring to the sketches, the apparatus is not elaborate and with modifications could easily be made in the average machine shop. The tests are: (1) subjecting a sample to a moist heat of 320 degrees Fahrenheit for four hours; and (2) a dry heat of 270 degrees Fahrenheit for two hours on another sample.

In order to obtain (1) pressure must be provided for. Fig. 1 shows the receiver filled partly with water. The sample is put in, the cap screwed down, and the thermometer placed in position, the gas burner being regulated by hand to give and regulate the temperature required. Fig. 2 shows the dry test. The sample is laid on a sheet of asbestos to prevent direct radiant heat, the thermometer being regulated as before.

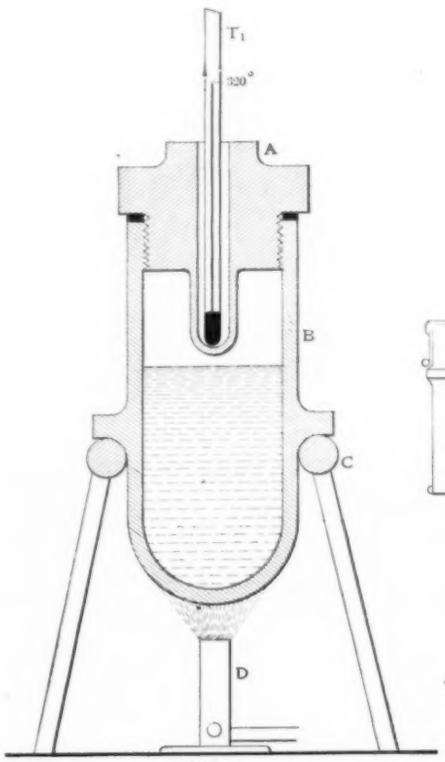


FIG. 1

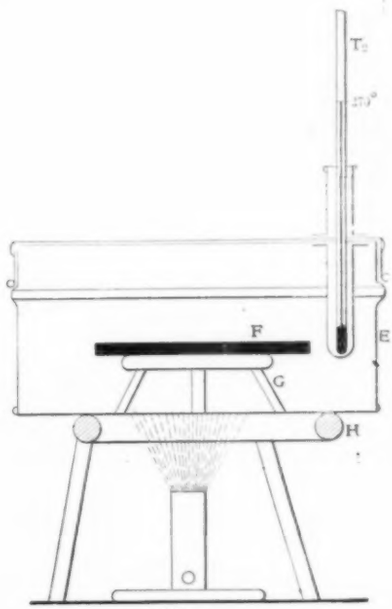


FIG. 2

MOIST AND DRY TESTING OF RUBBER

The apparatus Fig. 1 consists of a piece of hydraulic tube *B*, screwed at the neck to receive a suitable brass screwed hexagon cap *A*, standing on a tripod *C*. In Fig. 2 the covered box *E*, made from thin sheet copper, is provided with a suitable well for the thermometer, this bringing the bulk of the instrument level with the specimen lying on the asbestos sheet *F*, kept from the source of heat by the tripod *G*, the whole standing on the tripod *H*.

Tests Must Be Carefully Made

Constant supervision is essential to keep the temperature required, as a slight excess renders the test unfair and valueless.

When the samples are removed after the test, no appreciable loss of elasticity should be found, and the rubber should not be ruined. A slight discoloration is not detrimental.

A shop having steam pressure available should be able to rig up so as to require only occasional supervision for the wet test, steam at 75 pounds absolute corresponds for temperature. A length of pipe fitted with a reducing valve, suitably loaded, and a steam trap should be effective. A firm purchasing quantities of rubber-jointing material would find the small outlay involved by the tests amply repaid, as it enables reliable stuff to be purchased in the cheapest market.

It has proved itself valuable even in checking first-rate makers of rubber goods using the best materials. So far from being too severe a test for commercial material, it is in daily use, and if the test is stated when ordering, no difficulty should be found in purchasing.

Finally, it is believed that rubber to stand the tests cannot be made of re-manufactured material, and the cheaper and less satisfactory gums are excluded, making it necessary to use only Para rubber as the principal ingredient in the compositions termed commercially rubber; as if its use is known to the makers and the supply stands these tests, satisfactory results are obtained.

World's Marconi Stations

The wireless telegraph stations of the world have been located and catalogued by the Bureau of Equipment of the Navy Department of the United States, and the lists will shortly be published in book form. The number of stations in each country are: Belgium 1, Denmark 4, Germany 13, France 6, Great Britain and Ireland 43, Holland 8, Spain 4, Portugal 1, Gibraltar 2, Italy 18, Malta 1, Montenegro 1, Norway 1, Austria-Hungary 2, Roumania 2, Russia in Europe 8, Sweden 3, Turkey 6, Argentina 5, Brazil 5, Canada 5, Chili 1, Costa Rica 1, Mexico 2, Panama 2, Uruguay 1, United States 88 (10 of which are located in the United States possessions), Trinidad 1, Tobago 1, Andaman Islands 2, Burma 1, Hong Kong 1, China 5, Hawaii 5, Japan 2, Dutch East India 5, Russia in Asia 1, Egypt 2, Morocco 2, Mozambique 2, and Tripoli 1.—*Canadian Engineer.*

According to the Interstate Commerce Commission, the cost of pumping a barrel of oil through pipes, as used by the Standard Oil Company, is about 2 cents per 100 miles, which is very much less than by rail.

Molding a Bolt Cutter Bed—Method in Use at the Works of the Landis Machine Company

By Benj. F. Landis

The fact that so many interesting jobs in molding have appeared in the American Machinist within the past year, together with the comments of visitors to our shop on the uniqueness of our method in handling this piece, has induced me to describe it for the benefit of other readers.

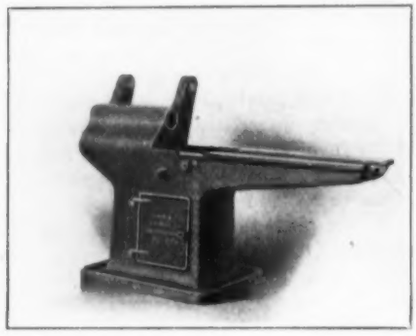


FIG. 1. THE BOLT CUTTER

A cut of the bed to be molded is shown in Fig. 1. It will be seen that the entire bed with all its bearings is cast in one solid piece. Formerly it had been made in two parts, the bed proper, and the head containing the bearings. It was then necessary to bolt the two together, and the consequent drilling, tapping, planing, making of screws and alining caused much extra work. With the advent of the new bed, cast in one solid piece, this expense was eliminated and as is frequently the case in new design, beside reducing the shop cost, it makes a more substantial job, being stronger and more rigid, and has a better appearance.

Some of its Features

When it was first drawn up it looked well on paper, but a conference with the foremen of the pattern shop and foundry developed numerous difficulties to be overcome before the assurance of a good mold could be given. A clearer idea of the requirements of the job and the obstacles likely to be encountered in devising a scheme for molding can be had from Fig. 2, a cross section and end view showing the general outlines of the piece. This shows the bare casting before any machining has been done upon it. The holes *A A* are formed so as to hold bushings permanently in place by means of babbitt. These bushings form the bearings for the drive shaft of the machine. The two arms supporting these bearings, in order to reduce the weight, are chambered from the central core as shown at *B B*. The main spindle bearing *C* is central with the bed and projects at each end beyond the casting, so that it may be accurately faced to the length required. The boss *D* on top of the bearing is used as a rest and gage for boring, and incidentally forms a convenient spot for the oil cup. Bosses *E* and *F* are for the yoke bearing and oil fender, respectively, and project on the inside, as shown. At the forward end of the guide a recess *G* is cast, the bottom of which slopes to the inside edge of the casting. This is intended to prevent the oil from the guides from running over the outside of the bed, as a groove is planed the full length of the guide, starting at the rear end flush with the surface and gradually deepening until it meets the bottom of the cored recess at the forward end. The inner edge of the planed groove is made flush with the outer edge of the carriage. The boss *H* is a seat for the rack. Its under surface is recessed beneath the face of the bed, forming a flat spot for the clamping screws. The lips *I* and web *J* are drips for the chips and oil, their inner edge overlapping the chip pan beneath. *K* is the pump spot, and *L L* the lugs for holding the bars which support the oil tank. The bottom or floor is solid, and the extending flanges at the bottom have a vertical lip on their outer edge which runs entirely around the base. This construction practically keeps any oil from leaving the bed, and the floor should be kept as clean as around any machine tool. These are the requirements as made out in the drawing room, and fortunately it was unnecessary to sacrifice any of them.

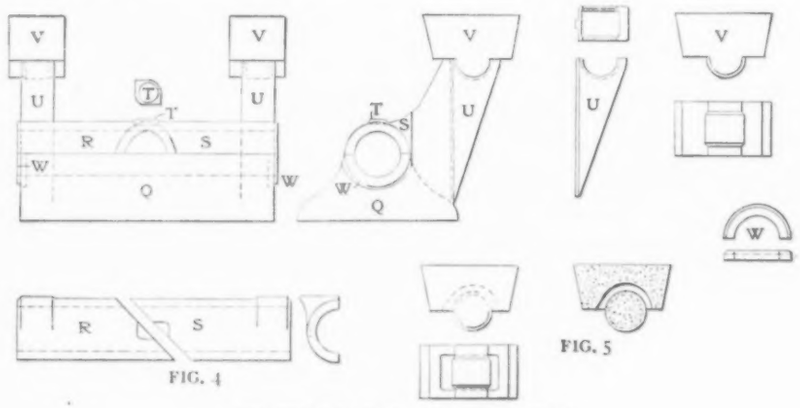


FIG. 4

FIG. 5

PATTERN FOR HEAD AND CORES USED

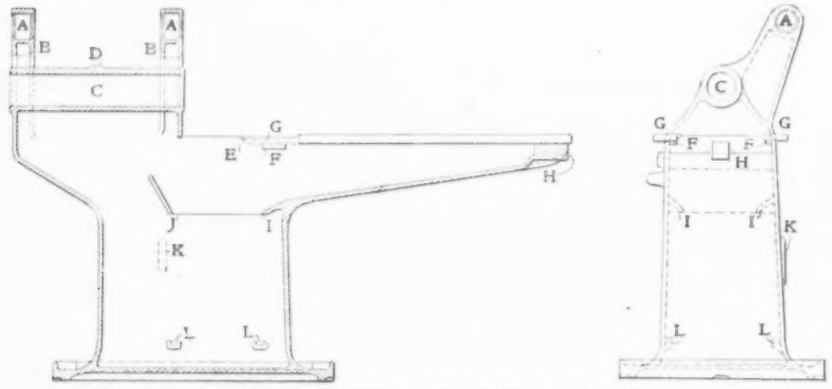


FIG. 2. SECTION AND END VIEW OF BED

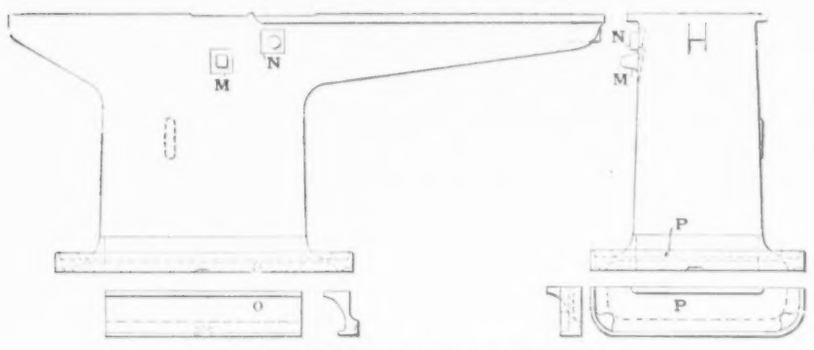


FIG. 3. PATTERN OF THE BOLT-CUTTER BED

How It Is Molded

The piece is molded in a specially constructed flask, with the guides and bearings down. This position was assumed so that no dirt would lodge in the finished parts, but would likely come to the bot-

tom of the bed. The ends of the flask are permanently hinged to its bottom, while the sides have lugs which pivot in sockets fastened to the base of the flask, and are so constructed that when the mold clears the pattern it may be lifted off and placed at any convenient place on the floor. The pattern of the bed proper is shown in Fig. 3. The bosses *M* and *N* are loose, and their bases which fit into the pattern are tapered to accommodate the circular movement given by the hinged side as the mold is withdrawn. The flanges *O* and *P*, are also loose, and as the mold is parted at the lower edge they are easily removed.

Pattern for the Head

At Fig. 4 is shown the pattern, and its details for the head which forms the spindle and drive shaft bearings. *Q* is the base. The cap for the spindle bearing is divided into the sections *R* and *S* on a diagonal line, as shown. On top of this cap is the loose boss *T*. *U U* are the arms for the drive shaft. These pieces are made with a dovetailed tongue of hardwood which fits into a similarly shaped groove in the base. Both are tapered so that when in place it binds on the taper, and there is no play. *V V* are loose core prints on top of the arms, and *W W* the rings forming the lower half of the projecting spindle bearing. A cut of the core, Fig. 6, shows plainly the arms which core the chambers above mentioned, also the door through which the vent is made, and

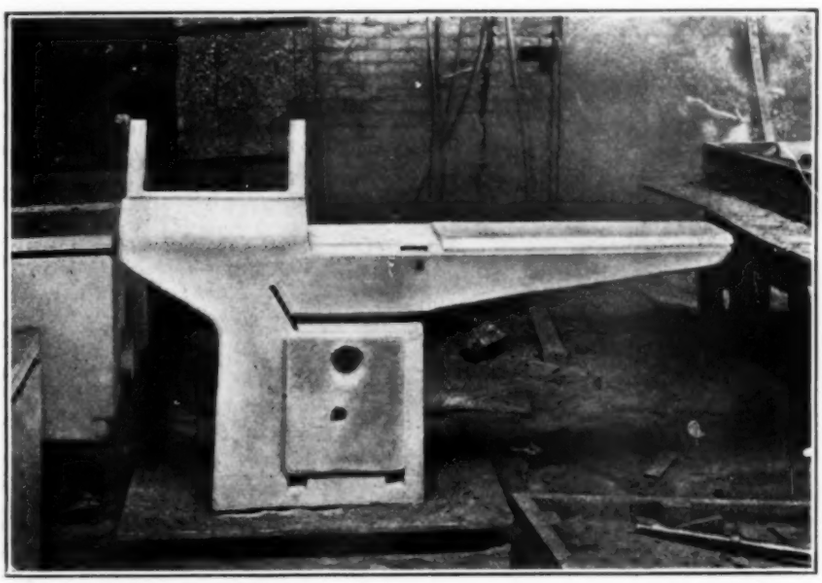


FIG. 6. CORE FOR BODY OF BOLT CUTTER

the slots forming the oil web and lips. The original design was drawn with a lip running from the rear as it now does from the front and sides, but as will be seen, this would have nearly severed the core, so the web running the whole way through was substituted. The box for forming this core is similar in construction to the flask, except that instead of the sides being hinged they are all separate, and are held together entirely by rods.

The core is made in two pieces, one forming the bed proper and another for chambering the head. There is, of course, a separate box for the head core, which is of very simple construction. The large core is made on an iron plate, which rests upon a metal truck. This truck runs on a track which leads into the core oven; thus the danger of breaking the core through handling is eliminated, for it is not lifted until after it has been baked.

Ramming the Mold

In making the mold it is necessary to ram from both top and bottom, and consequently the flask must be turned. This is done by a lug on each end, forming a bearing for a yoke hung on the crane. Before the pattern is placed in the flask, a dry-sand core of the unfinished diameter of the spindle bearing is so placed in position in the head pattern that both ends extend, thus forming its own prints. The pattern is then set in place, and the flask

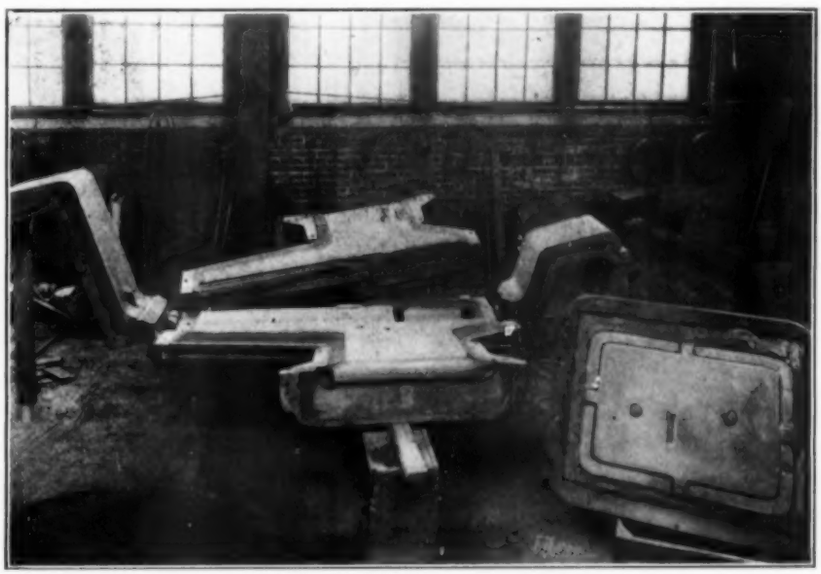


FIG. 7. HINGED FLASK OPEN TO RECEIVE CORE

closed, except the top. The sides and top of the mold (the bottom of the bed) are first rammed, after which the flask is turned and, through openings in the bottom, the top of the bed is rammed. When a good mold of the loose core prints *V V* has been made, they are withdrawn and the core shown in Fig. 5 is inserted in its place, after which the ramming is completed. It will be seen that this core is shaped so as to form both the cored hole and the cap on top of the arms.

The flask is again turned over and opened, the bosses and loose flanges are removed, and the pattern proper is lifted from the mold. The head pattern *Q* is then taken out, leaving the rings *W W*, the sections of the cap, *R* and *S*, and the arms *U U* intact. The rings are first drawn in and removed, then section *S* is revolved around the dry core and withdrawn, followed by section *R* in the same manner. The boss *T* is worked out from beneath the core, and the arms *U U* come out last. The mold is then complete, the core is lifted in place, and the flask closed and clamped ready to pour.

As there is no opening through the bottom of the bed it is necessary to hold the core with anchors to keep it from floating.

The positions in molding and the method of using the flask is shown in Figs. 7, 8 and 9. In Fig. 7 the mold is open, the pattern just having been removed. In Fig. 8 the core is in place, and in Fig. 9 the flask is partly closed around the core.

Cost Keeping in the Hardening Department

By E. R. Markham

In most up-to-date shops a more or less complete system of cost account is in vogue. Sometimes this system is very complicated and really amounts to very little other than for its moral effect on the men in charge of the various departments; in other cases it is systematically kept, and the cost of any operation on any lot of work may be ascertained quickly, and if desirable may be compared with that of similar operations on pieces of other lots. In large shops it is absolutely necessary to have such a system; in small shops it is advisable; and it is surprising how comparatively inexpensive the methods employed in some shops are, and yet they answer the purpose many times better than a more complicated method.

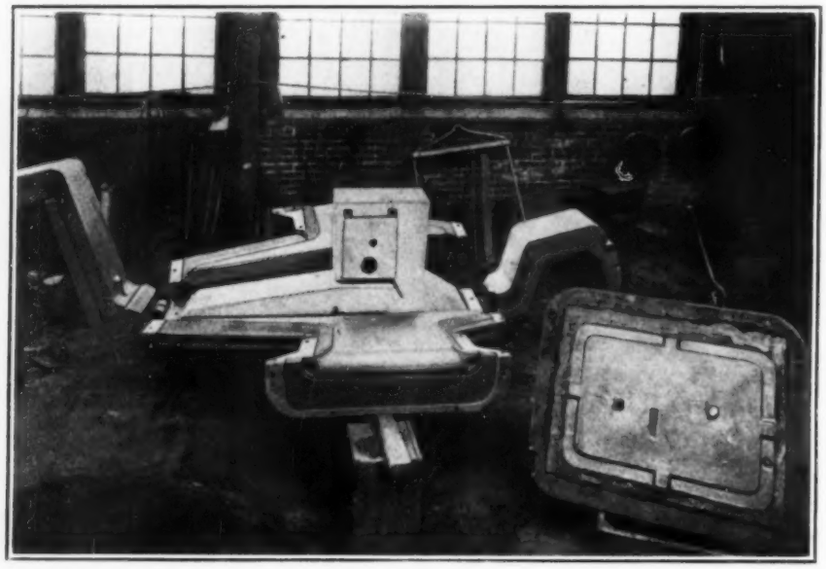


FIG. 8. CORE IN PLACE READY TO CLOSE MOLD

Now, while most up-to-date establishments keep a record of the cost of making the manufactured article and can tell at short notice how each department is being conducted, very few establishments "keep tabs" on the hardening department. I do not mean to be understood as advocating the employment of any system whereby the employees in this department would consider it advisable to attempt to save time, and in doing so heat steel more rapidly than is conducive to good results. Neither would I be understood as saying that because it cost 50 cents to harden a certain piece at one time, under other conditions and at another time it might not cost 75 cents, or even $1 to harden a similar piece. At one time we may harden a tool—for instance, a milling-machine cutter—and find it takes an hour to accomplish the result; at another time when we have a number to harden, we find that when one is partly heated we can place the second in the fire where it is not subjected to the full heat, and as it becomes heated we move it toward the point of the greatest heat, and by the time the first cutter has been dipped in the hardening bath and been reheated to remove hardening strains, the second one will be nearly ready to dip, and the third will have been placed in the fire, care being observed, of course, that we do not have so "many irons in the fire" that we cannot properly attend to all. It is apparent that, under the conditions considered above, six or more pieces may be hardened at a cost per piece far below what one would cost if treated alone. I have known cases where those in charge were foolish enough to tell the workman that a piece similar to the one he was to treat was hardened in one-half hour when in reality six were hardened in three hours; the man not knowing the circumstances attempted to duplicate the recorded result, overheated the lighter portions of the article, and when it was dipped in the bath the heat was not uniform, and as a consequence it went to pieces in the bath.

The above failure was not due to a cost-keeping system, but to an attempt on the part of the one in charge to get impossible results. Such a man cannot work as serious results in the manufacturing departments as when turned loose in the hardening room. The successful hardener will study to reduce the cost of hardening, but never to the sacrifice of quality; and many times the interested man will devise methods whereby he can harden pieces at a cost of cents where before it had cost dollars, and he will produce work as good, or better than before. Such men are valuable, and many shop managers are beginning to realize that in no department of their establishment is a brainy man more needed than in the one under consideration.

However, under the head of cost-keeping the actual amount of money expended to heat a piece of steel, dip it in the bath, and then draw the temper, should not be the only consideration. A tool that costs $50 may be hardened at a cost of $1; but if it is ruined as a result of carelessness or ignorance in the hardening room, the concern is out of pocket $51, and this department is at fault, and the amount should be charged up against it. If a tool is not properly hardened and does not do one-half the amount of work it should, this also should be placed against the department. In this way the brainy man is made to realize that it is up to him to send six perfectly-hardened tools out of

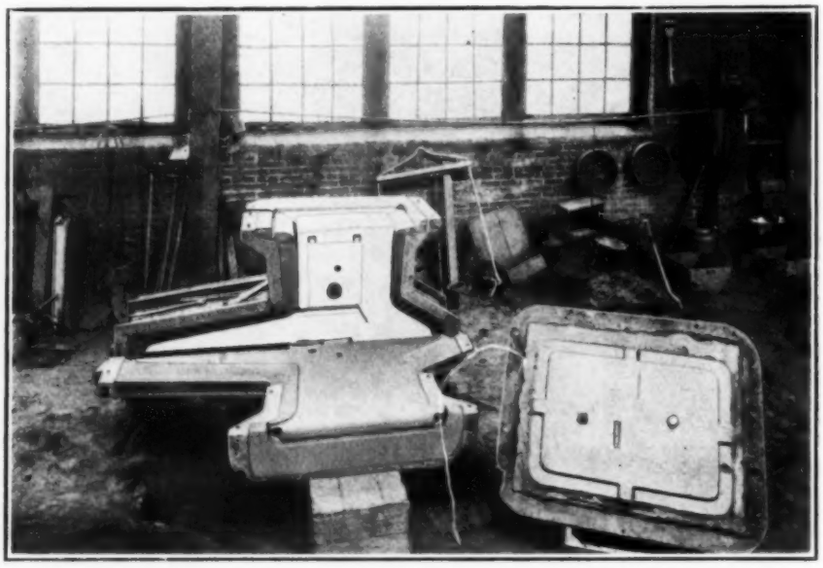


FIG. 9. CLOSING MOLD AROUND THE CORE

his department for every six perfect ones sent him. Of course, if the steel is at fault, then we have a different proposition; but he will find a way to keep tabs on the steel, and thus prevent imperfect steel being worked up into tools.

In many shops every bar of tool steel received is tested before it is cut up. I know of several shops where each end of each bar is tested, and as a result excellent results follow. At times tool steel varies in the same bar; this is an unusual occurrence, but I have seen such cases.

If a 12-foot bar of steel is to be cut up into blanks that finish from ¼ to ½-inch in length, and these pieces are to be machined into tools costing $2, $3, or $4 each, it is apparent that the very slight cost of cutting a piece of stock for a test piece from one end, or even from each end, of the bar may result in a decided saving, to say nothing of preserving the good-will of our customers, which is many times of much greater importance.

If a tool, for instance a punch press blanking die, will produce 100,000 pieces if properly hardened, it is apparent that if imperfectly hardened and only able to produce 10,000 pieces, it is a much more costly tool, as it would take 10 dies of this kind to duplicate the perfect one; to say nothing of the time wasted in the extra number of grindings the ten must have in order to produce the 100,000 pieces.

While all steel that is made into tools is not equally good, and various lots of stock used in manufactured goods do not machine alike, yet the fact remains that if the cost of doing work in the hardening department is kept on record, and the amount of work done with the tool is considered, it will be found to be a wonderful stimulus to the one in charge to devise methods whereby the efficiency of his department may be increased.

Setting Cores without Core Prints

By H. F. McCaslin

The illustrations herewith show several methods of using cores without core prints. While only a few of the ways are shown, the method can be applied in an infinite number of ways.

Fig. 1 shows the arrangement of cores to form an angular flange on a deep-setting web or rib. Applying the cores: a bed is struck off at the proper depth, core *A* placed in position and the pattern set in upon it; core *B* is now set up to pattern and core *A*, and resting upon a chaplet as shown to prevent it from ramming down. The pattern is now rammed up and drawn in the usual manner.

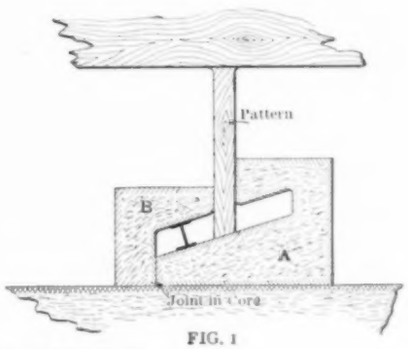


FIG. 1

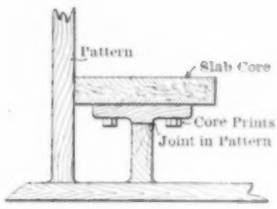


FIG. 2

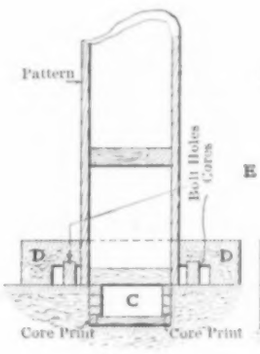


FIG. 3

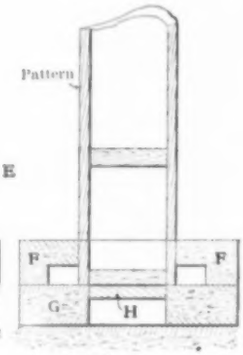


FIG. 4

SETTING CORES WITHOUT CORE PRINTS

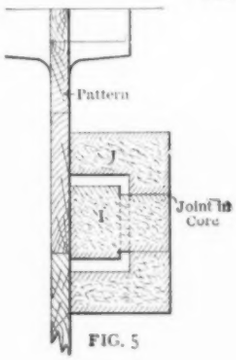


FIG. 5

FIG. 6

Fig. 2 shows the slab or covering core—a core that has no limit to its application, often saving a three-part flask or a more intricate cored mold, and expensive pattern. In some cases, especially in a deep setting, the slab core may have its objectionable features, on account of the difficulty in removing any sand which may fall into the mold during the drawing of the pattern. When the slab core is used in the cope, this objectionable feature is avoided, as the core may be placed in the depression provided for it, before or after closing the mold, and weighted or wedged down. The figure shows the slab core applied to an overhanging flange or foot, and the advantage of its application in this case will be readily seen. The pattern having been rammed up to the face or top of the flange, a surface is struck off. The flange being parted from the pattern, as shown, it is drawn out. The depression left vacant by it is covered with the core, and the ramming is continued and the pattern drawn as usual.

Making Pipe Flanges

Figs. 3 and 4 show two different methods of coring the flange on the pipe connections, when they are of such form one must be molded down. In arranging the cores, as shown in Fig. 3, the core print *C* is bedded in at about the right depth and a level surface struck off. The pattern guided by dowel pins is now set upon the core print and leveled up in position for ramming up. The two semi-circular cores *D* are now set up to pattern, as shown. In forming these cores, core prints can be placed in the core box to form depressions to receive the cores *E* for coring the bolt holes in the flange.

Using the arrangement of cores, as shown in Fig. 4, a level bed is struck off, and core *G* set in position; the pattern is located upon and in its proper position with this and with the projecting circular piece *H*. The work is now continued as in Fig. 3. It will be observed that core *G* makes a depression to receive the core that forms the interior of the pipe.

A Hollow Facing in a Rib

Fig. 5 shows a method of coring a round hollow facing upon a rib without the use of a core print. This simply consists of making the two cores and inserting core *I* into *J*, as shown. Now, if the outline of core *J*, which is of rectangular form, is secured in its exact location upon the rib, all that becomes necessary for the molder to do, when the ramming of the mold has reached this hight, is to set the arrangement of the cores up to the rib, and in its proper place, and proceed with the ramming, of course exercising a little care that the cores are not rammed out of place.

Fig. 6 shows the indispensable nail core, employed in coring babbitt anchors in babbitted bearings. This core can also be used in a variety of ways, such as coring the openings in baffle plates for furnace doors, cast-iron strainers and similar work.

Shop Talk About Steam Engines

Comparison of the Clearance and Leakage Losses in the Various Types of Poppet Valve, Slide Valve and Corliss Engines

BY C. W. CRAWFORD

Since the advent of the steam turbine as an unsuspected source of power—consisting, as it does, of a wholesale leakage of the entire product of the boilers through numberless sinuous open passages—the alleged equal of the reciprocating engine, a staggering sense of ignorance takes hold of the searcher after improvements. Preconceived notions of the force of steam and the application of it are no good now.

It is asserted that steam under high pressure blowing through a long crooked hole—or a series of holes—exerts as much power laterally as the same steam acting on a piston in the ordinary way. At first thought no one familiar with steam would believe such rot; yet that is what we are told every day in the papers. It is too well known for discussion that the direct force of an open jet of steam of any pressure is practically nothing, and it is really unbelievable that any number of such jets can exert the tremendous force they are doing every day. Of course the many thousands of increments of force exerted thousands of times a minute make up the aggregate. It has always been the care of the engineer to prevent leakage to the utmost; but such apparently reckless use of steam seems as absurd as blowing soap suds into a rat hole.

Time only can tell what will be the outcome of this innovation, but while the turbine is having its inning it is a good time for engineers to polish up a little on steam and its application by other means.

Wastefulness of Reciprocating Engines

It is not amiss to find out a better way of using steam if possible than the present one, in which a clearance waste of 2 per cent. to 10 per cent. is admitted and a probably much greater leakage waste. Builders of engines, as well as users, admit the clearance but deny the leakage, it being out of sight. Slide valves, although generally well fitted when new, leak steam after a very little wear. Accurately balanced slide valves wear very little, but their tendency is to become leaky; and as to unbalanced slide valves, the less said about them the better. All slide valves wear unequally—Corliss valves and all. Perhaps the latter are the worst of them all, for besides their sliding friction the side thrust of their stems tends to make them wabbly; and, any way, as they wear lower in their seats their motion becomes that of a pendulum whose center of motion is the valve stem and whose face motion cannot be described otherwise than as leaky. This is not as it should be in the twentieth century. There is no way of telling the amount of this leakage. The indicator does not measure it although it may indicate it. The valve may appear tight at one point in its stroke and very leaky at another. And when the valve and seat are of soft iron, as they generally are, the valve burrows into the seat in grooves and ruts, and after a year's wear, or less, there will not be a square inch of true face on it—flat valves will be worn in facets like a diamond, and Corliss valves will be anything but round.

There was a time when slide valves were in ill repute, when steam-tightness was a virtue and slide valves were rated only fit for sawmills, when poppet valves were recognized as the only valves fit to use in an engine of any importance. These poppet valves were steam tight, but they had the supposed fault of inordinate clearance, and they could only be used at slow speeds.

But under the old slow-speed régime they were superior to the slide valves and held their own until, upon the advent of high speeds, they were discarded. The clearance waste of the poppet valves of those times is now found to be not greater than that of the slide valves of the present, but all of them are bad enough and they all need reconstruction.

Authorities Ignore Leakage

There is no authority on leakage waste in engines. It is ignored in the books as if it did not exist, but there are plenty of excuses for excessive clearance, which is not called a waste by the builders of high-speed automatics, and they swear at you when you intimate such a thing. The users of engines are usually contented as long as they run quietly, and particularly the users of Corliss engines, which have come to be the autocrats of the engine room. Engines are generally bought for their beauty and their good behavior. The buyer of a high-class engine usually does not care what kind of an engine it is so it is a Corliss.

All the improvements in engines in fifty years have not brought the valve closer to the piston than 2 per cent. of the cylinder capacity, and in early cut-offs 10 to 30 per cent. of the volume of steam used, and together with the leakage, which is likely to be greater than the clearance, the percentage of useful effect is exceedingly meager. The old, discarded, slow-moving, noisy poppet-valve engine could not do worse than that. It does not require a college training to get on to these facts, but the mystery of it is that these conditions are not published in the books by those who ought to know.

Any fair comparison of engines must admit the faults as well as the merits of each. As a leak-provoking proposition the Corliss is about the worst of them all, in honest truth, but it is popular and an excellent machine to make money out of (although they do tell of shops in Ohio that make them for 3½ cents a pound).

The flat-faced slide valves, if balanced, are, in effect, similar to a piston valve without rings, and the fact that rings are used in some piston valves indicates that they become leaky without them. Therefore, the suspicion that flat-face valves also become leaky cannot be reasoned away. All sliding surfaces wear in proportion to their weight and surface, and as wear means leakage, all engines must become leaky, and if leakage occurs it must be in proportion to the pressure; and as high pressures are preferable, then the greater the leakage the better. This is ridiculous. Leakage is ridiculous any way, and all we gain by it is the satisfaction of being in good company—they all do it. Slide-valve engines are mostly of short strokes, and to secure early cut-off early closing of the exhaust follows as a consequence, and greater compression than is needed. Then to provide for excessive compression additional clearance must be admitted, in some cases 6 per cent. or more, at half stroke cut-off amounting to 12 per cent. of the volume.

Less Clearance Waste with Long Strokes

In excessively short strokes the percentage of clearance is exaggerated. There seems to be no good reason for strokes shorter than twice the diameter of the cylinder, except cheapness, for as rapid rotative speed as is needed can be had with the longer stroke and the crank-pin being further removed from the center, less power is wasted in punishing the shaft, and the clearance waste is less often repeated.

A favorite excuse for excessive clearance is the reaction after compression gives back the power expended, some of it; the rest goes up the 'scape pipe.

The fault of early exhaust closure is inherent in the slide valve at early cut-off and cannot be got rid of, and an early

cut-off in a single slide valve is a late one in a four-valve engine. When the exhaust closes about the time the cut-off takes place, all efforts at economy are in vain. It is generally admitted that a good slide-valve engine with less clearance and less compression, with a throttling governor and balanced valve, gives as good, or better, economy than the present automatic single-valve engine; but they are not popular because they are not "automatic."

Efficiency of Poppet Valves

The old poppet-valve engines, the few that are left, are now treated with the same contempt that the slide valves were once, or worse. But the truth about these engines is known to only a very few. The design and construction of the Mississippi steamboat engine is ingenious, and the work they do is marvelous. The side-wheel boats have separate engines, and when handled by an expert, they can be made to do everything but talk. At one time the largest engines in the world were on these boats, 36-inch cylinders, 12-foot stroke, working 180 pounds steam. Slide-valve engines could not maintain an existence in such work, and none were used. One of the principal reasons for their successful use was the steam tightness of their valves. No steam went up the 'scape pipe until it had done its work, and their economy was not worse than four pounds of coal per horse-power hour, exposed as they were to the atmosphere without jackets on cylinders or pipes. The clearance waste was not greater than that of the best Corliss engine of the present time, although it seemed enormous by measurement; the long strokes made the percentage comparatively low, and generally within 2 per cent. It would be a surprise to most engineers if they were to figure the clearance in the largest of the Mississippi river engines and find it less than 2 per cent., and the medium sizes very little more. The alleged excessive clearance of these engines has always been admitted, but after all they rate fairly with the Corliss engines, and less than half the clearance of the slide-valve automatics. Their piston speed was equal to any of the better class of modern engines, but their rotative speed was a snail pace compared to even the present medium-speed automatics, and that is the only valid reason for their rejection, except that they were noisy; and even their noise was not then considered objectionable until the Corliss and the better class of slide valves began to take their places. The rotative speed of these engines on steamboats was seldom over 25 revolutions per minute, and when used for other purposes not over 50 revolutions per minute. They were inferior to all other engines in respect to rotative speed, but equal to most others in piston speed, and are now found to be equal to the best in point of clearance and in range of fixed cut-off, susceptible to all adjustments for lead and compression, and decidedly superior to all others in point of steam tightness; and in durability they were immeasurably superior to every other engine.

The Corliss Engine

Corliss engines when first introduced were found to be superior in economy to all other engines, and particularly to the old shacks they superseded, during their first year's run.

Reports of these early Corliss engines being sold for the ostensible saving in fuel for five years, but really for the rate of saving for the first year while the engines were new, were numerously published in those times. Much credit for shrewdness is due Mr. Corliss in these transactions, in letting the purchaser hold the bag. Very few, if any, reports of economical Corliss engines are ever published after the engines are a year old, and at five years old their cards are frequently not presentable.

On the contrary poppet-valve engines only get down to their best work when a year old. The famous "Natchez" was (I think) the fifth boat of that name on which these engines were used, yet she fell only a little short in the race with the "R. E. Lee" from New Orleans to St. Louis, and she had poppet-valve engines which must necessarily have been in good condition. The superior advantage of these engines was in their valves being steam tight and continuing so. Their cut-off was fixed but changeable to any point in the stroke, usually half stroke. It doesn't require much sermonizing to define the superiority of these old poppet valves in respect of economy. Their weakness was in their slowness of speed and their noisy action. Both of these faults are fortunately now eliminated and noiseless running at high speeds is attained without sacrificing any of their previous good qualities, and with clearance reduced 50 per cent.

What is Required

If it can be demonstrated that a slide-valve engine can be operated at high speeds, without leakage and with 1 per cent. clearance, and indefinite durability and equal range of cut-off with other engines, then it will be entitled to retain its present exclusive position. If it can be demonstrated that a slide valve, balanced or unbalanced, when worn in facets, out of straight on its faces, even the thickness of thin tissue paper, still retains its steam tightness, then it is still entitled to hold its place. If it should ever come about that all steam engines were built of good, hard, close-grained iron, then there would be a hope that slide valves would remain longer steam tight—unfortunately a hope that may not come to fruition. It may as well be considered first and last that a valve 0.01 inch out of true will be leaky, and few valves a year old are otherwise. Try one with a straight-edge—it may be much worse. In fact all valves a year old are worn somewhat and are therefore somewhat leaky.

On the other hand a poppet valve—a double-beat one—may be somewhat leaky at the start (unless ground with steam on), but in a year its faces have worn together and it is steam tight. These are "truths that wake to perish never." A slide valve may be worn bright over its whole face and be very leaky at the same time. A good way to test this is to turn the valve end for end on its seat. It will prove rough sledding. Or take two Corliss valves that were originally alike and exchange them into each other's seats. It will be equal to extending the cut-off a few points—or perhaps save the application of another eccentric.

But here is a business too serious for frivolous contemplation. We have the Corliss engine at 80 revolutions per minute with a clearance of 2 per cent. and leaky valves, but with the best known cut-off and the best diagrams in the world; also the single-valve automatic at any speed to 300 revolutions per minute with a clearance of 6 per cent. or over, and leaky valves, and some kind of a cut-off, and a boomerang-shaped diagram; and also the old fashioned common slide valve at any speed with, say, 4 or 5 per cent. clearance, and an unbalanced leaky valve, and ¾-stroke cut-off and throttling governor.

The Poppet Valve is Here Again

And singularly enough we have the poppet-valve engine back again at any speed to 300 revolutions per minute with a clearance of 1 per cent., and steam-tight valves, and with a range of cut-off equal to any other, and a diagram practically equal to the best, and a durability practically unlimited; and absolutely noiseless. Here are the different varieties. The user of engines will take his choice.

Turbine Engines for Warships

The British Admiralty has decided to discard reciprocating engines, and in future will fit all classes of British warships with turbines. All battleships and cruisers of every class in the future will be thus equipped, though a few less important craft, such as gunboats and river boats, may still carry reciprocating engines. The cause of this departure in naval construction has been the great success of the "Dreadnought," and the fact that deficiencies in turbines as applied to warships are gradually being overcome. Hitherto the question of expense has been the chief drawback. Turbines in the past could only be built economically for one speed. If they were constructed for a speed of eight knots they were very satisfactory at that rate, but if they were constructed for 24 knots they were very expensive at less speed.

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Improved Apprenticeship Methods in Great Britain

The movement toward the introduction of improved methods of instruction for apprentices is making progress in Great Britain as well as in this country. We are in receipt of some particulars of their new plans from Clayton & Shuttleworth, of Lincoln, which appear to be very similar to those of Mr. Alexander in connection with the Lynn works of the General Electric Company.

Two aims are at the bottom of the plans of this company: first, to supplement the shop work with courses of instruction bearing directly upon the work in the shop, and, second, to give to all deserving apprentices a varied shop experience. Apprentices will be moved from one class of work to another, and diligence, skill and proficiency will be held to constitute a claim for transference to another class of work, the plan of keeping a boy for months on routine work simply because he has been skilful at it being avoided.

The firm has appointed a superintendent of apprentices, whose sole duties are to supervise, teach, promote and advise. The firm maintains its own school in the works, in which instruction is free, books and utensils being provided by the firm. Officials of the firm take part in the work of teaching and in general deal with subjects in which they are specialists. All of the trades which are usually found in a general engineering works are taught, and while an apprentice is not, in general, transferred from one trade to another, he is, so far as possible, given the opportunity of spending a certain portion of his time at various classes of work allied to the trade to which he becomes attached.

The firm will take apprentices at any age between 15 and 22 years of age, the term of apprenticeship being longer, however, in the case of the younger apprentices. This term, which extends through six years for apprentices of 15 years of age, is reduced to three years for those of 18 years and over in the case of machinists, toolmakers and patternmakers, and to four years in the case of molders, blacksmiths and boilermakers.

In the case of machinists, toolmakers and patternmakers the rate of wages begins at 5 shillings per week for the younger apprentices, this sum increasing to 8 shillings for the older apprentices during the first year, and increasing in all cases to 12 shillings for the last year. In the case of molders, blacksmiths and boilermakers the rate is uniformly higher throughout the term.

While the plans are not entirely matured, it is expected later on to work in harmony with a local technical school of which there is a good one in Lincoln.

The general aim of the movement is to attract older boys than have heretofore as a rule entered upon a term of apprenticeship, and especially those who have had a good schooling to start with. It is for this reason that higher rates of wages and a shorter term are offered to the older apprentices.

The "All-steel" Mail Car

Railway mail clerks and their acquaintances, and for that matter the entire public, will welcome the advent of a new type of steel mail car which has just been completed for trial on the Pennsylvania Railroad. Few classes of men are exposed to greater risk of life and limb in the performance of daily duties in the service of the general public than are the clerks who travel continuously over the various railroad lines handling the United States mails. With little or no warning in time of impending disaster, they not infrequently lose their lives or are incapacitated for the remainder of their days as the result of collision or derailment; in fact, few mail trains meet serious disaster without the names of one or more clerks being added to the casualty list. Therefore anything which tends to add security to their occupation may be hailed as of importance.

In addition to the danger to human life presented by the continuation in use of the ordinary type of mail car, there is another consideration that should hasten its abandonment at the earliest possible moment, and that is the monetary loss and serious inconvenience to business interests, due to destruction of valuable mail matter by fire and other mediums when railway trains are wrecked. While steel mail cars have been used in the past to a limited extent, there has usually been embodied considerable woodwork in their construction and equipment. The new car on the Pennsylvania road is said to be the nearest approach as yet to the all-steel car, and it is called by that name as it contains only 370 pounds of wood, 2840 pounds of composite and asbestos board, 3200 pounds of cement flooring, and a very small amount of rubber. Everything else, including mail cases, boxes and doors, is of metal. The interior arrangement of the car is along more convenient lines than adopted in the earlier types, thus facilitating the working of the mails; and structurally it is much stronger than any of its predecessors. It is 70 feet in length, or 10 feet longer than the standard heretofore. It is expected that the absence of inflammable materials in construction and equipment and the strengthened frame will enable the car to successfully resist fire and shock.

The X-ray is being practically used by the pearl fishers of Ceylon to show whether an oyster has pearls or not without opening. Those discarded are thrown back into the sea.

New Tools and Machine Shop Appliances

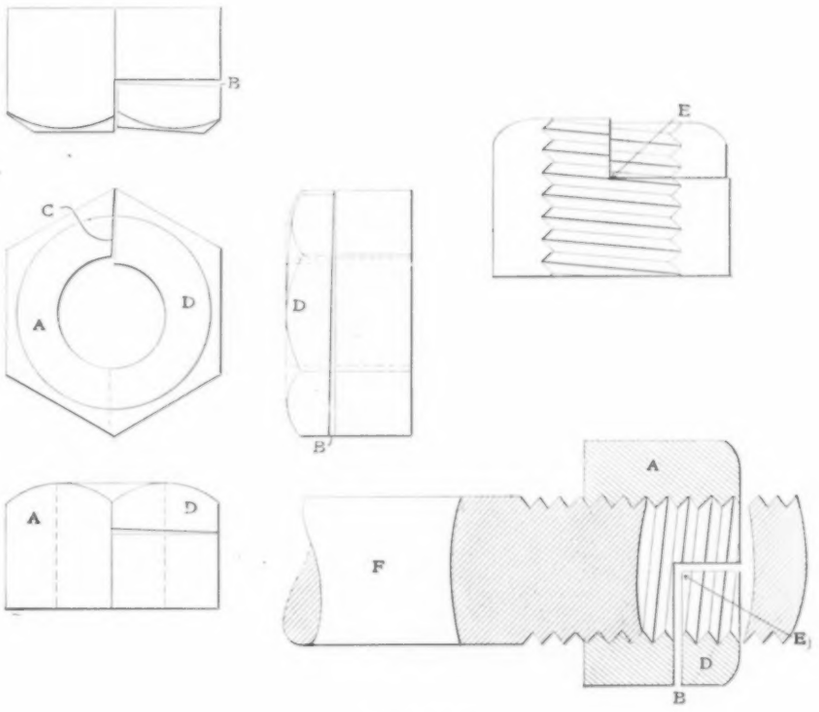
Showing the Progressive Development of Modern Shop Equipment and the Progress of Design in This Department of Work

THE LATEST INFORMATION

A Lock Nut

The illustration shows an ordinary nut so constructed that it securely locks itself upon the bolt or stud without the aid of washers or other appliances.

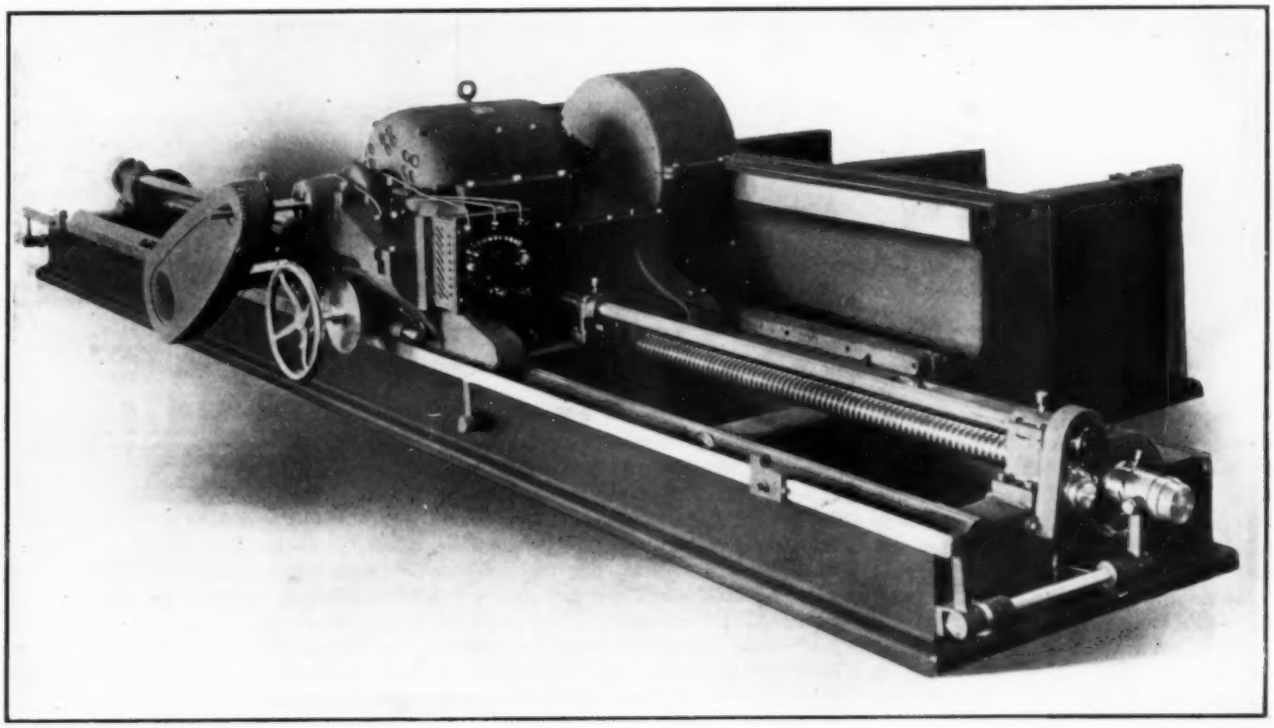
It consists of an ordinary nut *A*, which after being tapped has a saw cut *B* cut through it, a little way from the top, from corner to corner of opposite cants. Another saw cut *C* runs from the top of the nut and cuts into one end of the previously made cut *B* at one of the corners. The tongue piece *D* is then sprung in toward the center by a hammer blow. The nut is then case hardened. The tongue *D* acts as a spring and the edge *E* acts as a pawl on the soft threads of the bolt and prevents the nut from slacking off. The nuts are called the Bryar friction nut lock, and will be offered for sale in the near future by J. M. Smith, 568 St. Mark's avenue, Brooklyn, N. Y.



A LOCK-NUT

Large Motor-driven Edge Grinder

The half-tone shows a large motor-driven edge grinder adapted to grind work 160 inches long; it was designed



LARGE MOTOR-DRIVEN EDGE GRINDER

primarily to grind edges of heavy laminated safe plates, but is well adapted to do all kinds of heavy edging. The wheel carriage slides on one V way 5 inches wide and one flat way 6 inches wide, with bearing on the ways of 60 inches. The working part of the platen is 15x160 inches, but five projections each 30 inches long are provided to support extra wide plates.

The machine is driven by a 12½ horsepower Robbins & Myers direct-current motor, which operates both the grinding wheel and the wheel-carriage travel. The carriage is driven from one end of the motor armature shaft by means of a Morse silent chain, which connects to the splined shaft by bevel gears, alternately engaging with the 3½-inch lead-screw (1 inch pitch) by means of clutches. The emery-wheel cylinder, 20 inches diameter, mounted in a safety chuck, can be fed to the work from 1/1000 to 1/16 inch per stroke, automatically or by hand wheel, as desired. The emery wheel can be easily replaced when worn out by running the carriage to the extreme end of the stroke, which allows the wheel to be removed without interfering with any part of the machine.

The machine occupies floor space 10 feet 7 inches wide by 24 feet long, weighs approximately 23,000 pounds and was designed and built by The Safety Emery Wheel Company, Springfield, Ohio.

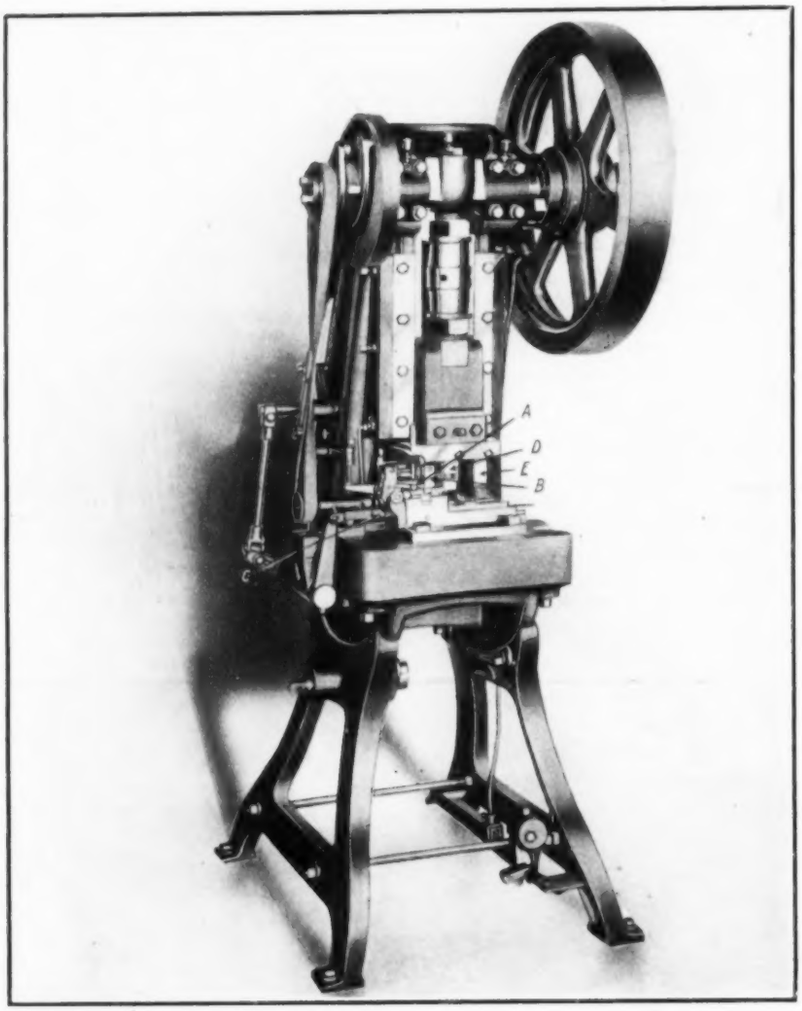


FIG. 1. AN AUTOMATIC PRESS

An Automatic Press

Aside from entirely doing away with handling the stock for the first operation, one of the chief objects of a feed on a power press is to carry the partly finished piece from one to another of the several dies until it is finished. Though the number of different combinations of feeds for the two purposes mentioned is large, and while some of them are quite common, the machine illustrated in Fig. 1, presents some features which are particularly interesting. It was specially designed for performing three operations simultaneously in the manufacture of a piece, as shown in Figs. 2, 3 and 4, although it may readily be adapted for other work.

The stock from which the piece is made is fed from a reel through the back of the press by means of a belt-driven single-roll feed *A*. This feed advances the strip to a stop just forward of the blanking punch *B*, which cuts the blanks, forces them through the die, and locates them on a push feed just under the die. This push feed *C* has a reciprocating motion across

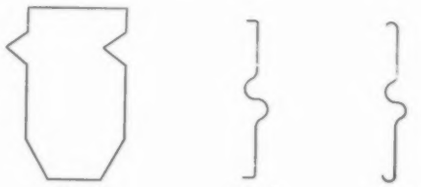


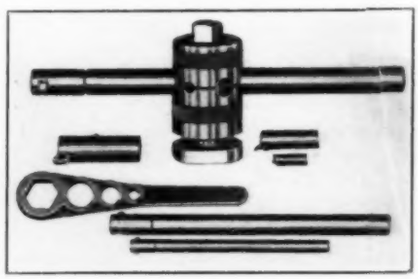
FIG. 2 FIG. 3 FIG. 4

WORK DONE BY THE PRESS

the bed of the press right and left, and is operated from the shaft by a cam in conjunction with a series of bell cranks, levers and connections. The carriers of the feed are arranged to receive first the cut blanks and push them under the second-operation punch *D*, where they are partly formed. After this operation two fingers carry the piece under the third punch *E*, where they are finished and then discharged at the next stroke of the press by fingers similar to those last mentioned. The press runs continuously at 80 strokes per minute, and as it operates three dies at each stroke its production of 240 operations is at least equivalent to the work of three presses fed by hand and run intermittently. The press was built by the E. W. Bliss Company, 1 Adams street, Brooklyn, N. Y.

A Multiple Boring-bar Tool Post

The illustration shows a lathe tool post for holding boring bars. The tool post is bored to receive three sizes of bars through it, the center bolt having a hole through it, in line with the centers of the lathe, large enough to take the largest size of bar. As the bars pass through the center of the device, there is no unnecessary overhang.



A MULTIPLE BORING-BAR TOOL POST

This tool post is made by Armstrong Brothers Tool Company, Chicago, Ill.

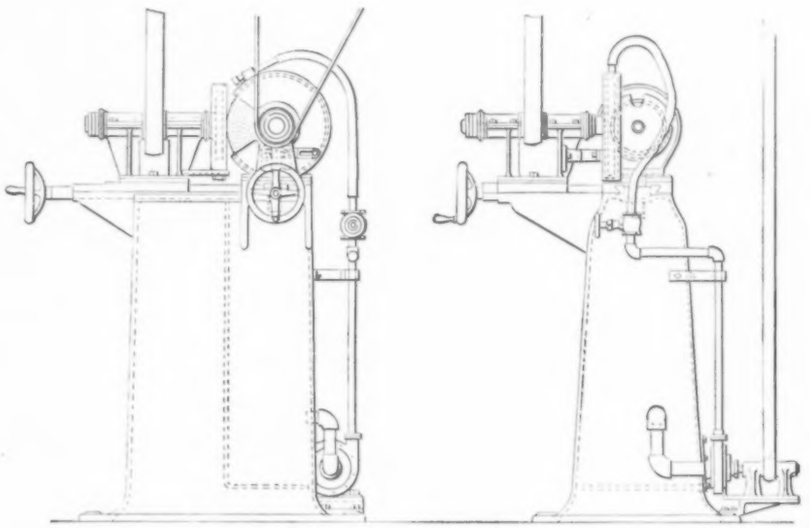
An Adjustable Reamer

The Cleveland Twist Drill Company, Cleveland, Ohio, has brought out an adjustable reamer, the body of which is of machinery steel with slots in it to receive the cutting blades. The blades are unevenly spaced to avoid chattering and are held rigidly in the slots by screws. When adjustment is necessary, the screws are loosened sufficiently to allow the blades to slide out. For backing, to increase the diameter, tin foil is used; this is supplied in thicknesses of 0.0005 and 0.001 inch. The blades can be packed out a number of times and can be reground to size. New blades can be had either singly or in sets.

Slitter and Disk Grinder

The slitter and disk grinder, shown by side and end elevations, is one which may, by minor changes, be readily adapted to grinding a large variety of work. It has a universal chuck for grinding punches, dies and a large variety of flat faces or circular pieces, and an expanding arbor, which is opened and closed by means of a screw. Both heads swivel to any angle, so that convex, concave or flat faces may be quickly ground. These heads are mounted on dovetailed ways gibbed to take up for wear, and are fed in and out by hand wheels and screws. The center of spindle is 6 inches above the ways and 40 inches above the floor. The spindle-bearing length is 4 inches, the diameter of spindle in bearing 1½ inches. Spindles on the heads are arranged with ring check-nuts to take up all end play. The machine may be arranged with a plain face plate (7 inches diameter) or a Walker magnetic chuck, or plain three- or four-jawed chucks. The wheel is 10x½ inches, and the distance between platen and wheel when new 6 inches. The machine can be arranged to grind either wet or dry. When grinding wet the wheel is inclosed, as shown by the cuts, by a hood, and pans are arranged to catch the water, which is conducted back into a large water tank in the base. The dirt and sediment settle to the bottom of the tank, while the clear water is drawn from above by means of the centrifugal pump and forced to the emery wheel and the work which is being ground.

This machine, which weighs 500 pounds, is made by the Bridgeport Safety Emery Wheel Company, Inc., Bridgeport, Conn.



SLITTER AND DISK GRINDER

Annual Convention of the National Metal Trades Association

The National Metal Trades Association held its ninth annual convention at Hotel Brunswick, Boston, on March 21 and 22. The membership of the association was well represented and the meeting was a very enthusiastic one.

Among the several interesting addresses was one by Samuel F. Hubbard on "The Commercial Value of Industrial Education," which we will publish in the near future.

The following officers were elected for the ensuing year: President, M. H. Barker, American Tool and Machine Company; first vice-president, F. K. Copeland, Sullivan Machinery Company; second vice-president, O. B. Kinnard, Kinnard-Haines Company, Minneapolis; treasurer, Wm. Lodge, Lodge & Shipley Machine Tool Company.

New Publications

MODERN AMERICAN LATHE PRACTICE By Oscar E. Perrigo. 416 pages, 6x9 inches; 314 illustrations. The Norman W. Henley Publishing Company, New York. $2.50.

Beginning with the history of the lathe the author traces its development up to the modern high-speed lathe and shows an ideal form of bed and ways, to which some are likely to take exception. Considerable space is devoted to change-gear devices used by various builders, which makes interesting reading for any mechanic. Chapters are devoted to testing the accuracy of lathes, to turning rests, and various attachments, and to lathe work of various kinds. It supplies much information that is often asked for, the illustrations are for the most part quite clear and we believe it is well worth the price to any mechanic who is interested in lathe work.

DIE VERBRENNUNGSKRAFTMASCHINEN IN DER PRAXIS; HANDBUCH FUER DIE ANLAGE, WARTUNG UND DEN BETRIEB DER MODERNEN VERBRENNUNGSKRAFTMASCHINEN. By H. Neumann, Ingenieur. 320 4¼x6¾-inch pages, with 137 illustrations. Dr. Max Jänecke, Verlagsbuchhandlung, Hannover. Price, pamphlet form, 4 marks; bound in linen, 4.40 marks.

This is a volume of a handy size, treating of the internal-combustion engine principally from the standpoint of the owner, attendant, machinist, etc., containing practically no thermodynamics nor mathematics beyond a few formulas for power, etc. The principles of the various types of these motors are briefly explained, as well as the elements of construction treated in a general way, not with the elaborate detail and attention to proportioning demanded by the designer, but sufficient nevertheless to give a very good idea of these matters. The characteristics of the various fuels—gaseous, liquid and solid—for motors and gas producers are discussed, followed by information on the installation of gas and oil engines, arrangements of the cooling and gas piping, handling of fuel oils, etc. Another part is a description, with many illustrations, of engines on the market (European), including the Diesel motor. Some attention is devoted to the care of gas engines, and to that prolific subject, the remedying of difficulties and troubles met with in their operation. After an explanation of the objects and methods of testing, last, but not least, we find a section on the cost of operation, which will be of much service in making a choice as to the power to be adopted in any particular case. It contains several tables of consumption of various kinds of fuel per horse-power for various loads, and the comparative costs of power from various sources. It appears to be, within its field, a very convenient and useful book.

Personal

P. D. Cook, Syracuse University, has accepted a position designing reinforced concrete in Chicago.

W. C. Smith has been appointed engineer of maintenance of way of the Northern Pacific Railroad.

Earl C. Haggett has been appointed assistant superintendent of the Brooks plant of the American Locomotive Company.

Loomis F. Goodale has been appointed supervising engineer of railroad construction for the U. S. Government in the Philippines.

F. C. Harper, chief engineer, Bagley Grader Company, has accepted a position in charge of heavy construction work in the Northwest.

F. T. Nelson, Valparaiso University, has recently accepted a position on an engineering corps connected with plant construction south of Chicago.

R. H. Mitchell, formerly with the Olds Motor Car Works, is now superintendent of the machine department of the Kansas City Motor Car Company.

A. B. Haugaard has accepted a position with the Builders' Supply & Construction Company in Alberta, Canada, as superintendent of building construction.

E. E. Brackett, recently manager of water and light plant for Pawnee City, Neb., has taken a position as instructor in electrical engineering at the University of Pennsylvania.

John C. Rahn, who has been connected with the Celluloid Company for nearly 20 years, has resigned and is now associated with the Charles Burroughs Company, Newark. N. J.

T. Ahlborn, formerly chief draftsman for the Wilmot Machinery Company, New Orleans, has taken a position as designer on some special mining machinery with Willis Shaw, Chicago.

E. M. McIlvain, formerly president of the Bethlehem Steel Company, has been elected president and general manager of the Robins Conveying Belt Company, Park Row Building, New York.

Robert E. Carrick has resigned his position as general engineer for Tucker & Vinton, New York City, and has accepted a position with the General Fireproofing Company, of Youngstown, O.

S. E. Freeman, late sales manager of the Sterling Consolidated Boiler Company for the New Orleans district, has accepted a position as superintendent of the Fuller Manufacturing Company, New Haven, Conn.

J. F. W. Bunsen, who for many years has been engaged in designing and erecting engineering works, power plants, etc., has entered the employ of Muralt & Co., engineers and contractors, New York City, and will take charge of their Southern office at Charleston, S. C.

Robert Pribram, who has held several temporary positions with consulting engineers in Chicago, has accepted a permanent position with the Aurora Pneumatic Tool Company, as mechanical draftsman and engineer. Mr. Pribram was for some time with the Ingersoll-Rand Company on similar work.

R. C. Wright, who has built the Vanderbilt Cup racers for the past two years for the E. R. Thomas Motor Company, Buffalo, N. Y., and acted as general foreman of the machine and model departments of that concern, has resigned to accept the position of general superintendent of the Auto Car Equipment Company, of Buffalo.

Charles A. Francis, who for the past three and a half years has been connected with the mechanical-engineering department of the Higher Technological School of Tokyo (Tokyo Kōto Kogyo Gakko) as instructor of practical mechanics, will sever his connection with that institution on April 1. Mr. Francis has not as yet formed any definite plans for the future, but may return to America at an early date.

Obituary

Robert H. Armstrong, of Armstrong, Walls & Co., New York City, died March 8.

John North, well known in New England as an inventor, died recently at Rocky Hill, Conn., where he had resided for many years. He was a native of Middletown. Among his best known inventions were a machine for making railroad spikes, a machine for folding the leaves of books, and a machine for setting type.

Delmar L. Macomber, manager of the Pittsburg office of the Pratt & Whitney Company, died suddenly at his home in that place, March 12. Mr. Macomber formerly resided in Hartford, Conn., and had traveled extensively in Europe in the interests of the Pratt & Whitney Company. In the early 90's he spent two years in Russia installing a large small-arms plant for the Government and later became works manager of a cycle plant in England. He returned to this country a few years ago and accepted a position of responsibility with the American Radiator Company, where he remained until reentering the service of his former employers in charge of the Pittsburg district.

Business Items

The Franklin Moore Company, Winsted, Conn., are making a large addition to their foundry. All equipment for this has been purchased.

The J. M. Carpenter Tap and Die Company, Pawtucket, R. I., has just broken ground for a new factory which will increase its manufacturing facilities 75 per cent.

A large shipment of vises was recently made to the Texas Central Railway Company, Texas, by the Pittsburgh Automatic Vise and Tool Company, of Pittsburg, Penn.

George D. Walcott & Son, Jackson, Mich., have been incorporated and the firm name changed to Walcott & Wood Machine Tool Company. The officers are E. E. Wood, president and general manager; C. L. Walcott, vice-president, and M. C. Walcott, secretary and treasurer.

The Robinson Tool Works, Pearl Lakes, Waterbury, Conn., a new concern, has just been started to manufacture the Hartford bench filing machine which is the die filing machine formerly manufactured by Henry & Wright Manufacturing Company, of Hartford. J. D. Robinson is proprietor.

The Northern Engineering Works, crane manufacturers, Detroit, Mich., are completing an addition to their plant, consisting of an erecting building for electric crane trolleys, served by a 10-ton electric traveling Northern crane. Also a two-story addition to serve as a tool room. The buildings are of brick and steel construction with saw tooth roofs.

Among the sales of rotary type, high-pressure blowers reported by the B. F. Sturtevant Company, of Boston, Mass., are equipments for Union Manufacturing Company, New Britain, Conn.; John Russell Cutlery Company, Turner Falls, Mass.; Greer Filter Company, Hamilton, Ohio; Riverside Boiler Works, Boston, Mass.; Lumley-Dodson Company, Norfolk, Va., and Steamship "Iroquois."

Modern Machinery and Engineering Company has been incorporated and acquired the business as selling agents for Potter & Johnston Machine Company and Landis Tool Company, formerly conducted by W. E. Flanders, offices at 309 Schofield Building, and 933 Monadnock Block, Chicago, Ill. Thomas F. Ahern, M. E., who has been manager of the Chicago office for the past two years and formerly with the Pratt & Whitney Company, is treasurer of the new company.

The G. M. Yost Company, of Mechanicsburg, recently received its charter from the State of Pennsylvania. Its officers are I. E. Yost, president; G. M. Yost, vice-president and general manager, and T. J. Kennedy, secretary and treasurer. This concern recently purchased the plant of Peter A. Frasse Company, New York. Its machine shop is now in operation and the construction of its foundry just commenced, and will probably be in operation by April 15. Equipment for both foundry and machine shop has been purchased.

Manufacturers

The Pacific Mills, Lawrence, Mass., will erect a new power house.

The Sutton Foundry Company, New Orleans, La., is erecting a new factory.

The Oakville (Conn.) Pin Company will build an addition to be four stories high.

The McPike Paper Company, Alton, Mo., will erect a new two-story factory building.

The Syracuse (N. Y.) Aluminum and Bronze Company will build a new $40,000 factory.

The A. L. Swett Iron Works Company, Medina, N. Y., is erecting a new brass foundry.

The Dahlstrom Metallic Door Company, Jamestown, N. Y., will build a four-story addition.

The plant of the Union Switch and Signal Company, at Swissvale, Penn., will be enlarged.

The Central Railway of Georgia, will erect a new shop at Macon, at a cost of over $1,000,000.

The National Pipe Bending Company, New Haven, Conn., is erecting a new plant at a cost of $25,000.

A. Leschen & Sons Rope Company, St. Louis, Mo., is building an addition to cost about $100,000.

The Orwigsburg (Pa.) Electric Light, Heat and Power Company was granted a franchise to erect a plant.

The Howell, McCrum Company, Norwich, Conn., manufacturing heaters, radiators, etc., will enlarge its plant.

J. C. O'Donnell, Deadwood, S. D., whose foundry was recently burned with a loss of about $20,000, will rebuild.

Plans are being prepared for a new factory for the National Electric Lamp Company, Cleveland, Ohio, to cost $50,000.

The plant of the New York Blower Works, at Bucyrus, Ohio, was almost completely destroyed by fire. It will be rebuilt.

The Dake Steam Turbine Company, Grand Rapids, Mich., has awarded contract for the construction of a new machine shop.

The Universal Caster and Foundry Company, Newark, N. J., has acquired some land on which a new factory will be erected.

The Topeka (Kan.) Canning Company, a new company capitalized at $20,000, is starting to erect its new plant. N. E. Copeland is president.

The Stover Manufacturing Company, Freeport, Ill., has commenced the erection of its new foundry which will be 180 feet long and 80 feet wide.

The South Atlantic Car Manufacturing Company, Savannah, Ga., whose plant was destroyed by fire some time since, will rebuild on the old site.

The Standard Underground Cable Company, Perth Amboy, N. J., has had plans prepared for a new building to be used for turning out rubber for its use.

Large car repair shops will be erected at Academy Junction, Maryland, for the Washington, Baltimore & Annapolis Electric Railroad Company.

The R. O. Stutsman Manufacturing Company, of Peoria, Ill., will move to Des Moines, where a new plant will be erected for the manufacture of peanut and coffee roasters, and a general foundry business. $100,000 will be invested.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Cox Computers, 75 Broad St., New York.

Caliper catalog free. E. G. Smith Co., Columbia, Pa.

Universal Test Indicator circulars free. H. A. Lowe, Lock Box 146, Cleveland, O.

Will buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Tools, dies and machinery built to order. Northwestern Machine Co., Detroit, Mich.

Expert machinist will consult and give advice. A. Frisk, 2240 Van Buren St., Chicago.

Light fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Special machinery to order, carbon and other molds specialty. O. Anderson, 30 Lawrence St., Newark, N. J.

Special machinery accurately built. Screw machine and turret-lathe work solicited. Robt. J. Emory & Co., Newark, N. J.

General machinists, toolmakers, screw machine products and manufactures. Gierth & Richards, 251-255 Elm St., Newark, N. J.

Wanted—A good second-hand Olsen testing machine; must be in good order; give particulars and state price. Address T. R. Co., Box 785, AMERICAN MACHINIST.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

Arrange with us to do your manufacturing; we build special machinery, special tools, etc. Lewis Blind Stitch Machine Company, 502 North Commercial St., St. Louis, Mo.

Regular machine and contract work to order at short notice. Electrical appliances, model and experimental work. Brown's, 748 Melrose Ave., New York City, near 156th St.

A reliable belt manufacturer has an overstock of double leather belting, from 2 to 6" inclusive, which he will sell at a bargain. Address "Reliable," care AMER. MACHINIST.

Large floors for rent, 60x210 ft. in thriving country town near Boston and Providence; steam and electric power, light and heat; railroad switch. Apply to Box 773, AMERICAN MACHINIST.

A large English firm of machine-tool importers, having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Isaac B. Owens, patent attorney, 100 Broadway, New York City, specialist in oil and gas engines, automobiles and automatic machinery. Patent applications entrusted to me will receive careful, personal attention, and patent secured which will protect.

Wanted—To buy patent, or manufacture under royalty, any specialty where high-grade grey iron castings constitute 60 per cent. or more of total cost; would also consider New England or Eastern rights to established article. "Founder," Care AMER. MACHINIST.

Draftsman, engineers learn automobile drafting and designing including the latest European and American practice; the only field not overcrowded; instruction in class room and by correspondence. The New York School of Automobile Engineers, 146 West 56th Street.

Advice; mechanical, practical and technical; tell me your needs. I'll tell you the cost; lowest estimates given on fine tools, dies and presses for sheet metal goods production; have you my books? Jos. V. Woodworth, M. E., Arbuckle Building, Brooklyn, N. Y., U. S. A.

We can build machinery for quick delivery. A shop building machine tools wishes to take contracts for the construction of machinery or anything that can be produced in a foundry and machine shop. Send drawings and specifications and estimates will be made with guarantee of quick delivery. We can refer to a standard line of tools now on the market as to the quality of workmanship. Box 75, AMERICAN MACHINIST.

Successful draftsmen drawing $125 to $200 monthly require thorough drafting room knowledge. As chief draftsman of engineering firm I know exactly the quality and quantity of experience and practical training you must have, and prepare you by mail, home instructions for above paying positions, which I furnish free anywhere. Complete highest grade drawing outfit, with German silver set of tools, value $13.85, free. Address Chief Draftsman, Div. 4, Eng.'s Equip't Co., (Inc.), Chicago.

Proposals will be received at the Bureau of Supplies and Accounts, Navy Department, Washington, D. C., until 10 o'clock a.m., April 9, 1907, and publicly opened immediately thereafter, to furnish at the navy yard, New York, N. Y., a quantity of naval supplies, as follows: Sch. 533: Hoisting engines. Sch. 535: Valve reseating machines, punch and shear, pneumatic countersinker, water tool grinder. Applications for proposals should designate the schedules desired by number. Blank proposals will be furnished upon application to the navy pay office, New York, N. Y., or to the Bureau. E. B. Rogers, Paymaster-General U. S. N. 3-15-07

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CALIFORNIA

First-class designer with 10 years' experience on steam engines; marine and stationary, blowing engines, air compressors and centrifugal pumps, auxiliary machinery and piping plans; desires position. Reply to Box 772, AMERICAN MACHINIST.

CONNECTICUT

Superintendent wishes to make a change, accustomed to fine and medium heavy interchangeable work; a designer of modern tools, jigs, and special machinery for rapid production. Box 784, AMERICAN MACHINIST.

General machine shop foreman; 37 and married, having 18 years' experience on special and automatic machinery, jigs, tools, etc.; wishes to change, manufacturing concern preferred. Best references. Box 779, AMERICAN MACHINIST.

ILLINOIS

Draftsman — Engineer in charge of large drafting room in the West wants work in the East. Box 776, AMERICAN MACHINIST.

Foreman pattern maker wishes to change location; large experience, progressive and systematic; up to date and successful; technical ability. Box 781, AMER. MACHINIST.

NEW JERSEY

Mechanical expert, shopman, competent designer, builder, improver on tools and machinery for manufacturing. References. Box 759, AMERICAN MACHINIST.

All-around mechanic; 29; technical education; 6 years at drafting, extensive experience in designing and building special machinery, tools and fixtures for modern manufacturing, desires permanent position with good firm, either shop or office. Box 783, AMERICAN MACHINIST.

NEW YORK

By technical college graduate; age 25; experience in mechanical drafting and with contracting engineer. Box 782, AMER. MACH.

Mechanical draftsman; 13 years' practical experience designing tools, machinery, etc., desires change. Box 780, AMER. MACHINIST.

Superintendent or master mechanic desires change; can control large volume economically, reduce operations and maintain interchangeability. Box 792, AMER. MACH.

Mechanical superintendent, employed, for personal reasons, desires to make a change; expert toolmaker, machinist, designer and manufacturing economist. Strong executive; salary secondary consideration. Box 764, AMERICAN MACHINIST.

Position as manager of works; held similar position seven years; can improve and design machinery; good mechanical, executive and business abilities; furnish best of references from concern where now employed. Box 374, AMERICAN MACHINIST.

Mechanical draftsman and designer (28); technical graduate with 3 years' practical experience on tools, fixtures and automatic machinery, good knowledge of manufacturing interchangeable parts, wants to change; position as assistant to master mechanic preferred. Box 767, AMERICAN MACHINIST.

OHIO

Sheet and bar metal working machines, special machines; technical graduate with wide range of experience and executive ability, at present chief draftsman, desires change of position. Box 768, AMER. MACH.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Wanted—First-class operator on Jones & Lamson turret lathe; also one first-class all-around machinist. The New Machine Co., Danbury, Conn.

Draftsman Wanted—Experienced in designing automatic machinery; give full particulars regarding experience, etc. The Bullard Machine Tool Co., Bridgeport, Conn.

ILLINOIS

Wanted—Patternmaker boss for pattern shop of steam engine manufacturer; pattern shop works about six men. Box 774, AM. M.

Wanted—Chicago; man of experience and expert ability as head of drafting room in factory of 300 men manufacturing carbonating and labor saving machinery; state qualifications fully, giving references and salary expected. Box 778, AMER. MACHINIST.

Wanted—Chicago; thoroughly competent draftsman, experienced in checking and systematizing the drawing up of specifications in factory of carbonating machinery; state qualifications fully, references and salary expected. Box 777, AMER. MACH

Wanted—A draftsman who has had a large experience in laying out buildings and also designing them for manufacturing machinery of comparatively large size; must be thoroughly familiar with the best arrangement of buildings and the design of them such as core rooms and ovens, pattern storage buildings, etc.; what is desired is a man who will spend some time to work out the best plan before the work will be put on paper; state fully what experience you have had along the above lines and also what salary expected; if a man showed the proper ability a connection of this kind might lead up to a permanent position. Address Box 754, AM. MACH.

INDIANA

Wanted—First-class engine erectors; per-

manent positions; large concern. Address Box 769, AMERICAN MACHINIST.

Wanted—Toolmakers; lathe hands, and assemblers; good wages; steady employment; Western Motor Co., Logansport, Ind.

Factory manager; experienced technical man; must be high grade, with business and mechanical ability; location, Indiana. Address Box 787, AMERICAN MACHINIST.

Machinery salesman; bright, experienced young man with exceptional ability and technical knowledge, acquainted with the eastern manufacturing trade; must be full of snap, originality and forcefulness, well able to create and hold trade for a reliable and well known establishment of the Central West. Give full particulars as to age, experience and qualifications. Address Box 786, AMERICAN MACHINIST.

MASSACHUSETTS

Wanted—Assistant mechanical draftsman; one used to shop methods and gear cutting preferred; state age, experience and wages expected. Address Boston Gear Works, Norfolk Downs, Mass.

Experienced mechanical draftsman wanted by manufacturing concern near Boston, Mass., for designing of jigs, fixtures and special machinery; permanent position for the right man; draftsman with practical machine shop experience preferred. Address with full particulars regarding age, education, experience and initial salary expected to Box 766, AMERICAN MACHINIST.

MICHIGAN

Machinists Wanted—First-class machine hands and floor hands on heavy work; steady employment assured. Northern Engineering Works, Detroit, Mich.

MISSOURI

Wanted—First-class adjusters accustomed to adding machine and typewriter work. Universal Adding Machine Co., St. Louis.

Wanted—Draftsman experienced in presses, dies and sheet metal tools; state if experienced in getting up catalogs and selling goods. The Fred J. Swaine Mfg. Co., St. Louis, Mo.

Draftsman Wanted—Large lead mining company, 65 miles south of St. Louis, Missouri wants draftsman for mechanical drafting and for making surface and underground maps; must be first-class freehand letterer and neat workman; man with knowledge of plotting and calculating survey field notes preferred; applicants please submit specimens of work and state salary wanted. Box 743, AMERICAN MACHINIST.

NEW JERSEY

Gas engine man wanted at once for installation and repair work. Steady employment. Apply, The Standard Motor Construction Co., 172 Whiton St., Jersey City, N. J.

Draftsman wanted by a firm in New Jersey; mechanical draftsman, quick and accurate, one acquainted with electrical preferred. State salary and experience. Box 755, AM. M.

Wanted—Tool, die and instrument makers accustomed to accurate, complicated work; steady work and good wages to thoroughly competent men; give references. Address Box 438, AMERICAN MACHINIST.

We are increasing our tool-making department and solicit applications from toolmakers and machinists who are experienced on fine and complicated work. Apply to Victor Talking Machine Co., Camden, N. J.

We have increased our plant and desire floor and vise hands for day work and lathe hands for night work. Good pay and steady work for good men. Address or apply at Pond Machine Tool Co., Plainfield, N. J.

Mechanical engineer—A Portland cement company located in Lehigh Valley district, which expects to build a new plant in about two years and use the present superintendent to build and operate new plant, wants engineer with experience (knowledge of cement machinery not necessary) to join present organization with view of becoming superintendent of present plant when new plant is started, provided he makes good; give details of experience and state salary expected. Address Box 749, AMERICAN MACHINIST.

Wanted—An experienced foreman of toolmaking department in a factory producing fine small mechanical work, on the interchangeable plan; the work done demands the highest skill and accuracy in fine tool work. An intimate knowledge of fine die and subpress work and modern up-to-date methods in all departments of fine tool making; it is absolutely essential that the applicant should have held a similar position elsewhere, and be possessed of good executive ability; the department employs from 30 to 40 men; references required. Box 789, AMER. MACH.

NEW YORK

Wanted—Experienced draftsman, toolmakers and machinists; give age, references and wages expected. Remington Arms Co., Ilion, N. Y.

Wanted—Metal patternmaker; one familiar with valves or fittings preferred; state age, experience and wages expected. Box 771, AMERICAN MACHINIST.

Foundry Foreman Wanted—An experienced practical foundry foreman in a large establishment doing work of miscellaneous character. Address by letter with references. Box 788, AMERICAN MACHINIST.

Foundry foreman; western New York; general line; one pound to five tons, new modern foundry; melting 20 tons, wants up-to-date man who can show he has produced results; state in full name, age, experiences, references and salary wanted to start. Address "Foundry," AMERICAN MACHINIST.

Wanted—A chief inspector for typewriter factory, to qualify; applicant must have had long experience in typewriter work and be a trained and practical mechanic, with executive ability; only those holding similar positions need apply; must be between 35 and 40 years of age; factory located in New York City. Box 791, AMERICAN MACHINIST.

Competent factory executive wanted; Western New York Manufacturing Company, manufacturing large line from medium interchangeable parts by automatic and semi-automatic machinery to large special units; capable man of high character, tact and experience in manufacturing lines with ability and business sense, who can show that he has produced results, and has capacity to rapidly advance to an executive position; state in full, name, age, past experiences, length of time different positions, responsibilities, references, etc. Address "Capable," AMERICAN MACHINIST.

OHIO

Wanted—First-class structural engineer capable of designing steel buildings, bridges, etc.; state age, qualifications, initial salary expected, etcy. Address Box 567, AM. MACH.

Wanted—Technical graduate experienced on gas engines, to take charge of gas engine testing department of large works. Address, giving full particulars. Box 157, Salem, O.

Tool Room Foreman Wanted—By an up-to-date manufacturing concern located in Ohio; must be able to design and supervise the making of small tools for both brass and iron work; write, stating fully, previous experience, references, age and approximate salary required. Box 790, AMER. MACHINIST.

PENNSYLVANIA

Wanted—First-class floor hands and fitters for machine-tool work. Colburn Machine Tool Company, Franklin, Pa.

Wanted—First-class draftsman on mill construction and equipment, technical man preferred. Box 775. AMERICAN MACHINIST.

Wanted—Capable diemakers to work on heavy drop-forge dies; steady work for the proper applicants. Apply, giving references, as well as wages expected. Box 705, AM. M.

Wanted—Machine shop foreman who has had experience and thoroughly understands making sheet metal dies and tools; give references and wages expected. Box 1023, Pittsburg, Pa.

RHODE ISLAND

We are continually adding to our force, experienced toolmakers, machinists and draftsmen on special tools, fixtures and models for light, high-grade machinery. Good wages and steady employment. Apply to Taft-Peirce Mfg. Co., Woonsocket, R. I.

VERMONT

Wanted—A draftsman, one with experience on textile machinery preferred. Box 770, AMERICAN MACHINIST.

Wanted—Foreman for erecting department in shop building machine tools; state experience and give references; good opening for the right man. Box 638. AMER. MACHINIST.

WISCONSIN

Large concern building excavating and railway machinery wants to correspond with first-class mechanical draftsmen with view to filling future vacancies as they occur; wants men now employed; give full experience and reasons for changing; shop experience great advantage; all letters acknowledged and held confidential. Box 919, AMERICAN MACHINIST.

WEST OF MISSISSIPPI

Wanted—A good superintendent capable of handling pattern shop, foundry and machine shop departments in a general jobbing, repairing and manufacturing shop located in a rapidly growing city of two hundred thousand inhabitants, center of a big lumbering country in the West; one who could invest about $10,000 preferred, an excellent opening for the right man. Full investigation demanded and given. Address Box 692, AMER. MACH.

For Sale

For Sale—Foundry, wood and iron machine shop. Box 74, Albion, N. Y.

For Sale—Machine shop; 250 feet ground, $4250. Morgan Dickort, Chattanooga, Tenn.

For Sale—Cyclopedia of modern shop practice, four volumes; bound in green morocco leather. Practically new; cost $18; will sell for $6. Address L. N. O., Box 425, Chicago, Ill.

For Sale—Plant suitable for machine shop and foundry. Splendid location, New York State. Good shipping point. Would take part interest in good manufacturing enterprise. E. W. Fulton, Lowville, N. Y.

Boilers—Battery of two 150 h.p. Babcock and Wilcox water tube boilers for 100 lb. pressure; first-class condition; complete, all trimmings. Nathan Manufacturing Company, 416 East 106th Street, New York City.

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Dodge & Day, Philadelphia, Pa.

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Kilbourne & Jacobs Mfg. Co., Columbus, Ohio.
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Gisholt Mach. Co., Madison, Wis.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Son Co., E., Windsor Locks, Conn.
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Ct.
Whiton Mach. Co., D. E., New London, Conn.

Chucks, Planer
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.

Chucks, Split
Rivett Lathe Mfg. Co., Boston, Mass.

Circuit Breakers
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps
Billings & Spencer Co., Hartford, Conn.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Tudor Mfg. Co., Worcester, Mass.

Clutches, Friction
American Tool & Machine Co., Boston, Mass.
Caldwell, Son & Co., H. W., Chicago, Ill.
Cresson Co., Geo. V., Phila., Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Wood's Sons Co., T. B., Chambersburg, Pa.

Clutches, Magnetic
Electric Controller & Supply Co., Cleveland, Ohio.

Coal Handling Machinery
Link-Belt Co., Philadelphia, Pa.

Coils
Standard Welding Co., Cleveland, Ohio.

Collectors, Pneumatic
Sturtevant Co., B. F., Boston, Mass.

Compound, Pipe Joint
Dixon Crucible Co., Joseph, Jersey City, N. J.

Compound, Slushing
Warren Bros. Co., Boston, Mass.

Compressors, Air
Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Boston, Mass.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas
Ingersoll-Rand Co., New York.

Conduit, Interior
Sprague Electric Co., New York.

Cones, Friction
Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps
Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E, New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work
Blanchard Machine Co., Boston, Mass.
Chapman & Co., J. B., Springfield, Mass.
Skinner Ship Bldg. & Dry Dock Co., Baltimore, Md.
Turner Mach. Co., Danbury, Conn.

Controllers and Starters, Electric Motor
Case Mfg. Co., Columbus, O.
Crocker-Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic
Lamson Consol. S. S. Co., Boston, Mass.
Link-Belt Co., Philadelphia, Pa.

Coping Machines
Bertram & Sons Co, Ltd., John, Dundas, Ontario, Canada.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Cork Inserts
National Brake & Clutch Co., Boston, Mass.

Corundum
See Grinding Wheels

Cost Systems
American Mechanical Calculator Co., Cincinnati, O.

Cotters
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.

Countershafts
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders' Iron Fdry., Prov., R. I.
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Mossberg Wrench Co., Central Falls, R. I.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction
Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing
Cresson Co., Geo. V., Phila., Pa.
Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counters, Machinery
Veeder Mfg. Co., Hartford, Conn.

Counting and Printing Wheels
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose
Ingersoll-Rand Co., New York.

Couplings, Shaft
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cresson Co., Geo. V., Phila., Pa.
Electric Controller & Supply Co., Cleveland, Ohio.
Link-Belt Co., Philadelphia, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Couplings, Shaft—*Continued.*
Standard Gauge Steel Co., Beaver Falls, Pa.
Wood's Sons Co., T. B., Chambersburg, Pa.

Cranes
Brown Hoisting Mach. Co., Cleveland, Ohio.
Case Mfg. Co., Columbus, Ohio.
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Maris Bros., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
United Engineering & Fdry. Co., Pittsburg, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines
Niles-Bement-Pond Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Crank Shafts
Bethlehem Steel Co., So. Bethlehem, Pa.
Leard, Wm. E., New Brighton, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles
Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas, and Ladles, Foundry
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups and Covers, Oil
Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.
Winkley Co., Detroit, Mich.

Cups, Grease
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cutters, Milling
Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Boker & Co., Hermann, New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Nash Company, Geo., New York.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines
Armstrong Bros. Tool Co., Chicago, Ill.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Hill, Clarke & Co., Inc., Boston, Mass.

Cutting-off Machines—*Continued.*
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Newton Mach. Tool Works, Philadelphia, Pa.
Nutter, Barnes & Co., Boston, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Fairbanks Co., Springfield, Ohio.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.

Cyclometers
Veeder Mfg. Co., Hartford, Conn.

Diamond Tools
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.

Dies, Sheet Metal
Amerian Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Kent & Co., Edw. R., Chicago, Ill.
Mossberg Wrench Co., Central Falls, R. I.

Dies, Sub-Press
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Opening
Boker & Co., Hermann, New York.
Errington, F. A., New York.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Mach. Co., Springfield, Vt.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins
Winkley Co., Hartford, Conn.

Drawing Boards and Tables
Alteneder & Son, Theo., Philadelphia, Pa.
Economy Drawing Table Co., Toledo, Ohio.
Mittineague Paper Co., Mittineague, Mass.
Soltmann, E. G., New York.

Drawing Materials
Alteneder & Son, Theo., Philadelphia, Pa.
Mittineague Paper Co., Mittineague, Mass.
Soltmann, E. G., New York.
Technical Supply Co., Scranton, Pa.

Drafting Machines
Universal Drafting Mach. Co., Cleveland, O.

Drilling Machines, Bench
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Goodell-Pratt Co., Greenfield, Mass.
Ingersoll-Rand Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.
Slate Mach. Co., Dwight, Hartford, Conn.

Drilling Machines, Boiler
American Tool Wks. Co., Cin., O.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, Ohio.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Electric
Chicago Pneumatic Tool Co., Chicago, Ill.

Drilling Machines, Multiple Spindle
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Fenn Mach. Co., Hartford, Conn.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.

Drilling Machines, Portable
Cincinnati Elec. Tool Co., Cin., O.
Contes Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial
American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bickford Drill & Tool Co., Cincinnati, O.
Detrick & Harvey Mach. Co., Baltimore, Md.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Fdry. Co., Jno. B., Cincinnati, O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co, New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Drilling Machines, Turret
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., B. F., Rockford, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co., Cincinnati, O.
Fenn Mach. Co., Hartford, Conn.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, Ohio.
Knight Machry. Co., W. B., St. Louis, Mo.
Marshall & Huschart Machry. Co., Chicago, Ill.

Drilling Machines, Upright
—Continued.
McCabe, J. J., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc, Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Vandyck Churchill Co., New York.
Wells Bros. Co., Greenfield, Mass.
Whitney Mfg. Co., Hartford, Ct.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Drills, Center
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand
Cincinnati Electrical Tool Co., Cincinnati, O.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.

Drills, Rail
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Foote-Burt Co., Cleveland, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Hisey-Wolf Mach. Co., Cincin., O.
Keystone Mfg. Co., Buffalo, N. Y.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

Drills, Rock
Ingersoll-Rand Co., New York.
Northern Elec. Mfg. Co., Madison Wis.

Drying Apparatus
Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos
Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
Eck Dynamo & Motor Works, Belleville, N. J.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. Co., Chicago, Ill.
Sprague Elec. Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincin., O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrical Supplies
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Elec. Co., New York.
Triumph Elec. Co., Cincinnati, O.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrically Driven Tools and Machinery
American Tool Wks. Co., Cin., O.
Cincinnati Electrical Tool Co., Cincinnati, O.
Crescent Forgings Co., Oakmont, Pa.
Electric Controller & Supply Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cincin., O.
Lincoln Motor Wks. Co., Cleveland, O.
Ransom Mfg. Co., Oshkosh, Wis.
Roth Bros. Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.

Elevators
Albro-Clem Elevator Co., Philadelphia, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.
Morse, Williams & Co., Phila., Pa.

Emery Wheels
See Grinding Wheels

Emery Wheel Dressers
American Emery Wheel Co., Providence, R. I.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Heald Machine Co., Worcester, Mass.
International Specialty Co., Detroit, Mich.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

Enclosures, Tool-room
Hart & Cooley Co., New Britain, Conn.
Merritt & Co., Philadelphia, Pa.

Engineering Appliances
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, O.

Engineers, Consulting, and Mechanical
Dodge & Day, Philadelphia, Pa.

Engineers, Electrical
Crocker-Wheeler Co., Ampere, N. J.
Dodge & Day, Phila., Pa.

Engines, Automobile
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Olds Gas Power Co., Lansing, Mich.

Engines, Gas and Gasolene
Automatic Mach. Co., Bridgeport, Conn.
Backus Water Motor Co., Newark, N. J.
Blaisdell Machinery Co., Bradford, Pa.
Foos Gas Engine Co., Springfield, Ohio.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Jacobson Mach. Mfg. Co., Warren, Pa.
New Era Gas Engine Co., Dayton, O.
Olds Gas Power Co., Lansing, Mich.
St. Marys Mach. Co., St. Marys, Ohio.
Struthers-Wells Co., Warren, Pa.

Engines, Steam
Buffalo Forge Co., Buffalo, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Engravers
Bormay Engraving Co., New York.
Standard Engraving Co., New York.

Engraving Machinery
Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads
Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition Machinery
Machinery Exchange, Boston, Mass.
Philadelphia Bourse, Phila., Pa.

Expanders, Tube
Nicholson & Co., W. H., Wilkes-Barre, Pa.

Factory Equipment
Lyon Metallic Mfg. Co., Aurora Ill.

Fans, Electric
Backus Water Motor Co., Newark, N. J.
Crocker-Wheeer Co., Ampere, N. J.
Diehl Mfg. Co., Elizabethport, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust
Backus Water Motor Co., Newark, N. J.
Buffalo Forge Co., Buffalo, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Files and Rasps
American Swiss File & Tool Co., New York.
Barnett Co., G. & H., Phila., Pa.
Hammacher, Schlemmer & Co. New York.
Nicholson File Co., Prov., R. I.
Reichhelm & Co., E. P., New York.

Filler, Iron
Felton, Sibley & Co., Phila., Pa.

Filing Machines
Cochrane-Bly Co., Rochester, N. Y.
Detrick & Harvey Mach. Co., Baltimore, Md.
Henry & Wright Mfg. Co., Hartford, Conn.
Simplex Mfg. Co., New York.

Flexible Shafts
Chicago Flexible Shaft Co., Chicago, Ill.
Coates Clipper Mfg. Co., Worcester, Mass.

Forges
Boynton & Plummer, Worcester, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Buffalo Forge Co., Buffalo, N. Y.
Ingersoll-Rand Co., New York.
Miner & Peck Mfg. Co., New Haven, Conn.
Prentiss Tool & Supply Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Forgings, Drop
Bethlehem Steel Co., So. Bethlehem, Pa.
Billings & Spencer Co., Hartford, Conn.
Crescent Forgings Co., Oakmont, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Page-Storms Drop Forge Co., Springfield, Mass.
Wyman & Gordon Co., Worcester, Mass.

Forgings, Hydraulic
Bethlehem Steel Co., So. Bethlehem, Pa.
Wyman & Gordon Co., Worcester, Mass.

Forgings, Machine
Dyson & Sons, Jos., Cleveland, O.

Forgings, Steel
Baldwin Steel Co., New York.
Bethlehem Steel Co., So. Bethlehem, Pa.
Crescent Forgings Co., Oakmont, Pa.
Heppenstall Forge & Knife Co., Pittsburg, Pa.
Kent & Co., Edwin R., Chicago, Ill.
McInnes Steel Co., Corry, Pa.
Tindel-Morris Co., Eddystone, Pa.
Wyman & Gordon Co., Worcester, Mass.

Foundry Furnishings
Adams Co., Dubuque, Iowa.
Ingersoll-Rand Co., New York.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Fuel Economizers
Sturtevant Co., B. F., Hyde Park, Mass.

Furnaces, Annealing and Tempering
American Gas Furnace Co., New York.
Chicago Fexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Tate, Jones & Co., Pittsburg, Pa.

Furnaces, Enameling
American Gas Furnace Co., New York.

Furnaces, Gas
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Obermayer Co., S., Cincinnati, O.
Westmacott, J. M., Prov., R. I.

Furnaces, Melting
American Gas Furnace Co., New York.
Nash Company, Geo., New York.
Turner Brass Works, Chicago, Ill.

Furnaces, Oil
Tate, Jones & Co., Pittsburg, Pa.

Furniture, Machine Shop
Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.
Manufacturing Equip. & Engineering Co., E. Boston, Mass.
Merritt & Co., Philadelphia, Pa.
New Britain Mach. Co., New Britain, Conn.

Gas Blowers and Exhausters
Sturtevant Co., B. F., Hyde Park, Mass.

Gages, Recording
Bristol Co., Waterbury, Conn.

Gages, Standard
Brown & Sharpe Mfg. Co., Providence, R. I.
Henry & Wright Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Wks., Jno. M., Gloucester, City, N. J.
Slocomb Co., J. T., Prov., R. I.
Starrett Co, L. S., Athol, Mass.

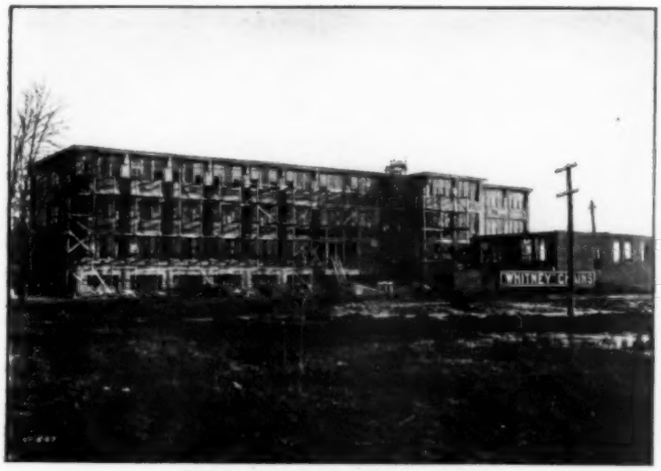
Gages, Steam
Crosby Steam Gage & Valve Co., Boston, Mass.
Williams Valve Co., D. T., Cincinnati, Ohio.

Gear Cutting Machinery
Adams Co., Dubuque, Iowa.
Bair & Gazzam Mfg. Co., Pittsburg, Pa.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Bilgram, Hugo, Philadelphia, Pa.
Brown & Sharpe Mfg. Co., Providence, R. I.
Clough, R. M., Tolland, Conn.
Eberhardt Bros., Mach. Co., Newark, N. J.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant-Lees Mach. Co., Cleveland, Ohio.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Morse, Williams & Co., Phila., Pa.
Newton Machine Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.

"Whitney" Chains

In 1907 will break all previous records for durability

We are moving into our new fire-proof factory building and will operate both plants, old and new, until we are fully settled so our production may be steadily increased with no interruption.



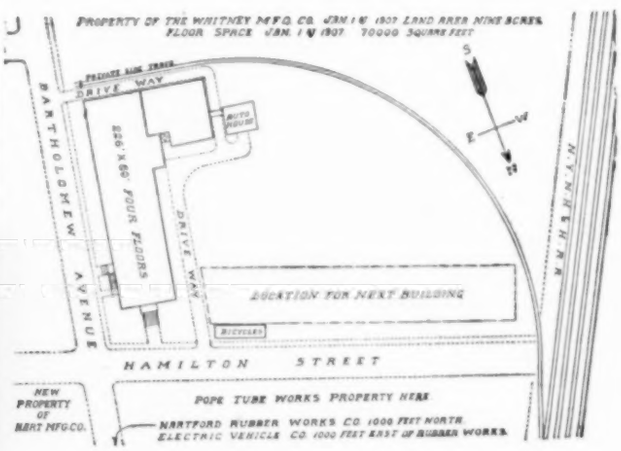

PROPERTY OF THE WHITNEY M'F'G. CO. JAN. 1ST 1907. LAND AREA NINE ACRES.
FLOOR SPACE JAN. 1ST 1907. 70000 SQUARE FEET.
DRIVE WAY
BARTHOLOMEW AVENUE
220 X 69' FOUR FLOORS
AUTO HOUSE
LOCATION FOR NEXT BUILDING
HAMILTON STREET
NEW PROPERTY OF HART MFG CO.
POPE TUBE WORKS PROPERTY NEAR
HARTFORD RUBBER WORKS CO. 1000 FEET NORTH.
ELECTRIC VEHICLE CO. 1000 FEET EAST OF RUBBER WORKS.

PHOTO. TAKEN JANUARY 6, 1907.

This cut gives an idea only of the plant which we believe will be the finest and most complete in existence for the manufacture of High Grade Driving Chains.

"Whitney" Chains

HAND AND WEIGHT FEED MILLING MACHINES, and The Woodruff Patent System of Keying

are Standard with most American Builders of Automobiles, Commercial Cars, Machinery, etc.

The Whitney Mfg. Co.

Hartford Connecticut

Gear Cutting Machinery —*Continued.*
Spacke Mach. Co., F. W., Indianapolis, Ind.
Walcott & Son, Geo. D., Jackson, Mich.
Whiton Machine Co., D. E., New London, Conn.

Gear Testing Machinery
Gisholt Mach. Co., Madison, Wis.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Gears, Cut
Bair & Gazzam Mfg. Co., Pittsburg, Pa.
Bilgram, Hugo, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., Chicago, Ill.
Cresson Co., Geo. V., Phila., Pa.
Davis, Rodney, Philadelphia, Pa.
delphia, Pa.
Earle Gear & Machine Co., Phila-
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant Gear Wks., Boston, Mass.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Horsburgh & Scott Co., The, Cleveland, Ohio.
Morse, Williams & Co., Phila., Pa.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Patterson, Gottfried & Hunter, Ltd., New York.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Wks., Cleveland, O.
Simonds Mfg. Co., Pittsburg, Pa.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Taylor-Wilson Mfg. Co., McKees-Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Son, Geo. D., Jackson, Mich.

Gears, Molded
Caldwell & Son Co., H. W., Chicago, Ill.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Greenwald Co., I. & E., Cin., O.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Walcott & Son, Geo. D., Jackson, Mich.

Gears, Rawhide
Boston Gear Works, Norfolk Downs, Mass.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Horsburgh & Scott Co., Cleveland, O.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Works, Cleveland, O.

Gears, Worm
Albro-Clem Elevator Co., Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Morse, Williams & Co., Phila., Pa.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Simonds Mfg. Co., Pittsburg, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Son, Geo. D., Jackson, Mich.

Generating Sets
Burke Electric Co., Erie, Pa.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

Generating Sets—*Continued.*
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, O.

Generators, Gas
American Gas Furnace Co., New York.

Gibs
Standard Gauge Steel Co., Beaver Falls, Pa.

Graphite
Dixon Crucible Co., Jos., Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Grinders, Automatic Knife
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.

Grinders, Center
Cincinati Electrical Tool Co., Cincinnati, O.
Coates Clipper Mfg. Co., Worcester, Mass.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cin., O.

Grinders, Cock
Windsor Mach. Co., Windsor, Vt.

Grinders, Cutter
Bath Grinder Co., Fitchburg, Mass.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, O.
Crocker-Wheeler Co., Ampere, N. J.
Garvin Machine Co., New York.
Gould & Eberhardt, Newark, N. J.
Greenfield Mach. Co., Greenfield, Mass.
Heald Machine Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Niles-Bement-Pond Co., New York.
Norton Co., Worcester, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Rivett-Dock Co., Boston, Mass.
Wells & Sons Co., F. E., Greenfield, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinders, Cylindrical
Bath Grinder Co., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Heald Machine Co., Worcester, Mass.
Norton Grinding Co., Worcester, Mass.

Grinders, Disk
Bath Grinder Co., Fitchburg, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Diamond Mach. Co., Prov., R. I.
Gardner Machine Co., Beloit, Wis.
Heald Machine Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Iroquois Mach. Co., New York.
Ransom Mfg. Co., Oshkosh, Wis.
Rowbottom Machine Co., Waterbury, Conn.
Safety Emery Wheel Co., Springfield, O.

Grinders, Drill
Heald Machine Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinders, Internal
Bath Grinder Co., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Greenfield Mach. Co., Greenfield, Mass.
Heald Machine Co., Worcester, Mass.
Rivett Lathe Mfg. Co., Boston, Mass.

Grinders, Internal—*Cont.*
Wells & Sons Co., F. E., Greenfield, Mass.

Grinders, Piston Ring
Heald Machine Co., Worcester, Mass.

Grinders, Portable
Cincinnati Electrical Tool Co., Cincinnati, O.
Heald Machine Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
U. S. Electrical Tool Co., Cin., O.

Grinders, Saw
Tindel-Morris Co., Eddystone, Pa.

Grinders, Tool
Armstrong Bros. Tool Co., Chicago, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Fitchburg, Mass.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Electrical Tool Co., Cincinnati, O.
Diamond Mach. Co., Prov., R. I.
Gisholt Mach. Co., Madison, Wis.
Gould & Eberhardt, Newark, N. J.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Heald Machine Co., Worcester, Mass.
Hill, Clarke & Co., Inc., Boston, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Landis Tool Co., Waynesboro, Pa.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Niles-Bement-Pond Co., New York.
Ransom Mfg. Co., Oshkosh, Wis.
Rivett Lathe Mfg. Co., Boston, Mass.
Safety Emery Wheel Co., Springfield, O.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
U. S. Electrical Tool Co., Cincinnati, O.
Vandyck Churchill Co., New York.
Vitrified Wheel Co., Westfield, Mass.
Whitney Mfg. Co., Hartford, Ct.
Wilmarth & Morman Co., Grand Rapids, Mich.

Grinding and Polishing Machinery
Abrasive Material Co., Philadelphia, Pa.
American Emery Wheel Co., Providence, R. I.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Fitchburg, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Electrical Tool Co., Cincinnati, O.
Coates Clipper Mfg. Co., Worcester, Mass.
Crocker-Wheeler Co., Ampere, N. J.
Diamond Mach. Co., Prov., R. I.
Goodell-Pratt Co., Greenfield, Mass.
Graham Mfg. Co., Prov., R. I.
Greenfield Mach. Co., Greenfield, Mass.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Heald Machine Co., Worcester Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Iroquois Mach. Co., New York.
Landis Tool Co., Waynesboro, Pa.
Marshall & Huschart Machry. Co., Chicago, Ill.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Norton Co., Worcester, Mass.
Norton Grinding Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Ransom Mfg. Co., Oshkosh, Wis.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vandyck Churchill Co., New York.

Grinding and Polishing Machinery —*Continued.*
Vitrified Wheel Co., Westfield, Mass.
Wells Sons Co., F. E., Greenfield, Mass.

Grinding Wheels
Adams Co., Dubuque, Iowa.
American Emery Wheel Co., Providence, R. I.
Builders' Iron Foundry, Providence, R. I.
Carborundum Co., Niagara Falls, N. Y.
Cortland Cor. Wheel Co., Cortland, N. Y.
Diamond Mach. Co., Prov., R. I.
Hampden Corundum Wheel Co., Brightwood, Mass.
Niles-Bement-Pond Co., New York.
Norton Co., Worcester, Mass.
Pike Mfg. Co., Pike, N. H.
Safety Emery Wheel Co., Springfield, O.
Vitrified Wheel Co., Westfield, Mass.
Whitney Mfg. Co., Hartford, Ct.
Worcester Emery Wheel Co., Worcester, Mass.

Grindstones and Frames
Athol Machine Co., Athol, Mass.
Cleveland Stone Co., The, Cleveland, Ohio.
Niles-Bement-Pond Co., New York.
Pike Mfg. Co., Pike, N. H.

Gun Barrel Machinery
Diamond Mach. Co., Prov., R. I.
Pratt & Whitney Co., Hartford, Conn.

Hammers, Drop
Billings & Spencer Co., Hartford, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Bradley & Son, C. C., Syracuse, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Gould & Eberhardt, Newark, N. J.
Miner & Peck Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.

Hammers, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Hammers, Power
Beaudry & Co., Inc., Boston, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Scranton & Co., New Haven, Ct.

Hammers, Steam
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bethlehem Fdry. & Mach. Co., So. Bethlehem, Pa.
Bradley & Son, C. C., Syracuse, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Crescent Forgings Co., Oakmont, Pa.
Marshall & Huschart Machinery Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Handles, Machine Tool
Cincinnati Ball Crank Co., Cincinnati, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Hangers, Shafting
Cresson Co., Geo. V., Phila., Pa.
Link-Belt Co., Philadelphia, Pa.
Wood's Sons Co., T. B., Chambersburg, Pa.

Heaters, Feed Water
Sturtevant Co., B. F., Hyde Park, Mass.

Heating and Ventilating Apparatus
Buffalo Forge Co., Buffalo, N. Y.
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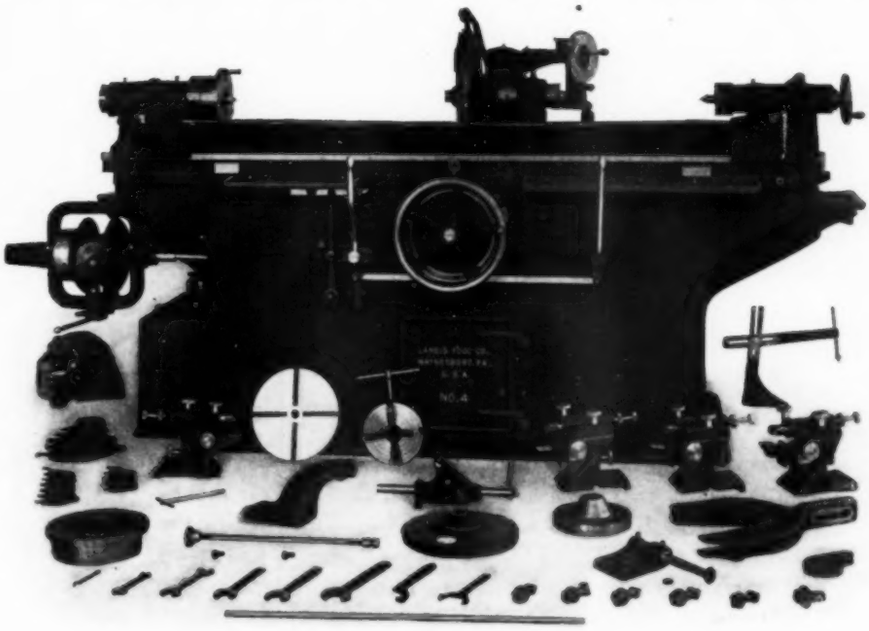
Do You Want True and Accurate Parts?



Then while you know that they cannot be produced on a lathe, why do you stick to old-time methods? Parts which are absolutely true and accurate are produced on a "Landis" in one-third the time and the work is of higher grade and better finished.

If you are interested in economy, get the Catalog.

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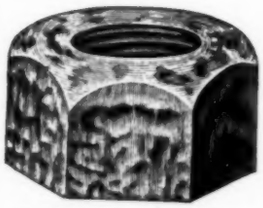
THE MILTON MANUFACTURING COMPANY,

MILTON, PENNSYLVANIA.



Case Hardened Hexagon Nuts.

Semi-Fin. Hexagon Nuts.

Manufacturers:--

The use of COLD PUNCHED NUTS, Full Finished or Finished Case Hardened, "Milton" Brand, on your Machinery will guarantee to you the perfect finishing touches essential in rounding out a good first-class Machine or Tool in point of workmanship. In the manufacture of all styles of Cold Punched Nuts we use DOUBLE REFINED BAR IRON of our own manufacture, which is made uniform in quality. Our product is perfectly Hexagonal in shape, with sharp corners and well finished. The Finished Case Hardened Nuts show on their exterior surfaces in coloring The Works of Art. We will Gladly send samples for test and comparison upon request.

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Pratt & Whitney Co., Hartford, Conn.

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Brown Hoisting Machinery Co., Cleveland, O.
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Lamson Consolidated S. S. Co., Boston, Mass.
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Main Belting Co., Phila., Pa.
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Sturtevant Co., B. F., Boston, Mass.
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Case Mfg. Co., Columbus, Ohio.
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Curtis & Co. Mfg. Co., St. Louis, Mo.
General Electric Co., New York.
General Pneumatic Tool Co., Montour Falls, N. Y.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Sprague Electric Co., New York.
Yale & Towne Mfg. Co., New York.

Hoists, Hand
Case Mfg. Co., Columbus, O.
Chisholm & Moore Mfg. Co., Cleveland, O.
Harrington, Son & Co., Edwin Philadelphia, Pa.
Moore Co., Franklin, Winsted, Ct.
Yale & Towne Mfg. Co., New York.

Hoists, Pneumatic
Chicago Flexible Shaft Co., Chicago, Ill.
Chisholm & Moore Mfg. Co., Cleveland, O.
Curtis & Co. Mfg. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Northern Engineering Works, Detroit, Mich.

Hones
Chicago Pneumatic Tool Co., Chicago, Ill.
Pike Mfg. Co., Pike, N. H.

Hose
Chicago Pneumatic Tool Co., Chicago, Ill.
Rhoads & Son, J. E., Phila., Pa.
Sprague Electric Co., New York.

Hot Blast Apparatus
Sturtevant Co., B. F., Boston, Mass.

Igniters, Gas Engine
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Indicators, Speed
Niagara Tachometer & Inst. Co., Niagara Falls, N. Y.
Starrett Co., L. S., Athol, Mass.

Indicators, Speed, Peripheral
Warner Instrument Co., Beloit, Wis.

Indicators, Steam Engine
Crosby Steam Gage & Valve Co., Boston, Mass.

Indicators, Test
Norton Co., Worcester, Mass.

Industrial Railways
Hunt Co., C. W., West New Brighton, N. Y.

Injectors
Desmond-Stephan Mfg. Co., Urbana, Ohio.
International Specialty Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Inspection and Tests
Hunt Co., Robert W., Chicago, Ill.

Instruments, Electric
General Electric Co., New York.

Iron Bar
Milton Mfg. Co., Milton, Pa.

Jacks, Hydraulic
Bethlehem Fdry. & Mach. Co., So. Bethlehem, Pa.
Burroughs Co., Chas., Newark, N. J.
Joyce-Cridland Co., Dayton, O.
Watson-Stillman Co., New York.

Jacks, Planer
Armstrong Bros. Tool Co., Chicago, Ill.

Kettles, Soda
Brown & Sharpe Mfg. Co., Providence, R. I.
Mfg. Equip. & Engineering Co., E. Boston, Mass.

Key Seaters
Baker Bros., Toledo, O.
Chattanooga Machinery Co., Chattanooga, Tenn.
Lapointe Mach. Tool Co., Hudson, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
Morton Mfg. Co., Muskegon Heights, Mich.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Whitney Mfg. Co., Hartford, Ct.

Keys, Machine
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Gauge Steel Co., Beaver Falls, Pa.
Whitney Mfg. Co., Hartford, Ct.

Knives, Machine
Coes Wrench Co., Worcester, Mass.

Knurls
Hammacher, Schlemmer & Co., New York.

Lamps, Arc
General Electric Co., New York.
Turner Brass Works, Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Lathe Attachments
American Tool Wks. Co., Cin., O.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Bradford Machine Tool Co., Cincinnati, O.
Fitchburg Machine Works, Fitchburg, Mass.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Rivett Lathe Mfg. Co., Boston, Mass.
Seneca Falls Mfg. Co., Seneca Falls, N. Y.
Sloan & Chace Mfg. Co., Newark, N. J.

Lathe Dogs
American Tool & Machine Co., Boston, Mass.
Armstrong Bros. Tool Co., Chicago, Ill.
Besly & Co., Chas. H., Chicago, Ill.
LeCount, Wm. G., So. Norwalk, Conn.
Pratt & Whitney Co., Hartford, Conn.
Tindel-Morris Co., Eddystone, Pa.

Lathes
American Tool & Mach. Co., Boston Mass.
American Tool Wks. Co., Cin., O.
Automatic Mach. Co., Bridgeport, Conn.
Barnes Co., W. F. & John, Rockford, Ill.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.

Lathes—*Continued.*
Blount Co., J. G., Everett, Mass.
Bradford Mach. Tool Co., Cin., O.
Bullard Mach. Tool Co., Bridgeport, Conn.
Champion Tool Works Co., Cincinnati, O.
Detrick & Harvey Mach. Co., Baltimore, Md.
Diamond Mach. Co., Prov., R. I.
Dreses Mach. Tool Co., Cin., O.
Fairbanks Co., Springfield, O.
Fitchburg Machine Works, Fitchburg, Mass.
Garvin Mach. Co., New York.
Gisholt Mach. Co., Madison, Wis.
Greaves, Klusman & Co., Cin., O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hendey Mach. Co., Torrington, Conn.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Lodge & Shipley Mach. Tool Co., Cincinnati, O.
McCabe, J. J., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
Motch & Merryweather Machinery Co., Cleveland, O.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rahn-Carpenter Co., Cincinnati, Ohio.
Schumacher & Boye, Cincinnati, Ohio.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Seneca Falls Mfg. Co., Seneca Falls, N. Y.
Springfield Mach. Tool Co., Springfield, O.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.
Von Wyck Mach. Tool Co., Cincinnati, O.
Walcott & Son Co., Geo. D., Jackson, Mich.
Wells Sons Co., F. E., Greenfield, Mass.
Whitcomb-Blaisdell Mach. Tool Co., Worcester, Mass.
Windsor Mach. Co., Windsor, Vt.

Lathes, Automatic Screw-Threading
Automatic Machine Co., Bridgeport, Conn.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.

Lathes, Bench
American Watch Tool Co., Waltham, Mass.
Blount Co., J. G., Everett, Mass.
Fenn Mach. Co., Hartford, Conn.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Rivett Lathe Mfg. Co., Boston, Mass.
Seneca Falls Mfg. Co., Seneca Falls, N. Y.
Stark Tool Co., Waltham, Mass.
Sloan & Chace Mfg. Co., Newark, N. J.
Waltham Machine Wks., Springfield, Mass.
Waltham Watch Tool Co., Springfield, Mass.

Lathes, Boring
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Lathes, Brass
Bardons & Oliver, Cleveland, O.
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Dreses Mach. Tool Co., Cincin., O.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Springfield Mch. Tool Co., Springfield, O.
Warner & Swasey Co., Cleveland, Ohio.
Windsor Mach. Co., Windsor, Vt.

Lathes, Extension
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Prentiss Tool & Supply Co., New York.

Lathes, Foot Power
Barnes Co., W. F. & Jno., Rockford, Ill.
Seneca Falls Mfg. Co., Seneca Falls, N. Y.

Lathes, Speed
Bertram & Sons Co., Ltd., John, Dundas, Ontario, Canada.
Blount Co., J. G., Everett, Mass.
Seneca Falls Mfg. Co., Seneca Falls, N. Y.

Lathes, Pulley
Kerr Machine Tool Co., Cincinnati, Ohio.

Lathes, Wood
Prentiss Tool & Supply Co., New York.
Seneca Falls Mfg. Co., Seneca Falls, N. Y.

Letters, Pattern
Butler, A. G., New York.

Levels
Starrett Co., L. S., Athol, Mass.

Lifting Magnets
Electric Controller & Supply Co., Cleveland, O.

Lockers, Clothes
Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.
Merritt & Co., Philadelphia, Pa.

Locks
Yale & Towne Mfg. Co., New York.

Locomotives, Electric
General Electric Co., New York.

Lubricants
Besly & Co., Chas. H., Chicago, Ill.
Dixon Crucible Co., Jos., Jersey City, N. J.

Lubricators
Besly & Co., Chas. H., Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, O.

Machinery Dealers
Frevert Machinery Co., New York.
Garvin Mach. Co., New York.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
McDowell, Stocker & Co., Chicago, Ill.
Motch & Merryweather Co., Cleveland, O.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentiss Tool & Supply Co., New York.
Toomey, Frank, Philadelphia, Pa.
Vandyck Churchill Co., New York.
Wormer Mach. Co., C. C., Detroit, Mich.

Machinists' Small Tools
Athol Machine Co., Athol, Mass.
Bemis & Call Hardware & Tool Co., Springfield, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Boker & Co., Hermann, New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Hammacher, Schlemmer & Co., New York.
Millers Falls Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Sawyer Tool Mfg. Co., Fitchburg, Mass.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.
Starrett Co., L. S., Athol, Mass.
Wyke & Co., J., East Boston, Mass.